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Volume XLVIII July-September 1993

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MYCOTAXON

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NEW SAND-INHABITING RHODOCYBE (BASIDIOMYCETES, AGARICALES)

Mauro Ballero* e Marco Contu**

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Summary

A new species of Rhodocybe growing in association with Juniperus phoenicea L. is described from sand dunes in central Sardinia. The new species is closed to Rhodocybe parilis (Fr.) Sing but is different in colour and spore size.

The sand dunes of central Sardinia have been studied during several years by these Authors in collaboration with several other sardinian mycologists. Some results of these investigations have been published in four reports (Contu, 1988 a , 1988 b ; Ballero e Contu, 1990 a, 1990 b) in which notes and description on some very interesting findings have been offered.

The extensive studies carried out leed us, yet, to the conclusion that several further investigations are in order because a lot of rare, exotic or even undescribed agarics do exist in these still not well explored places.

In the present comunication a new species of Rhodocybe found in association with Juniperus phoenicea L. in the mediterranean vegetal association Pistacium-Juniperetum macrocarpae Caneva, De Marco, Mossa is fully described and commented. In association with Juniperus phoenicea L. a lot of very interesting additional records were made but only a single new species has been published (Ortega & Contu, 1991).

Rhodocybe ochraceopallida, spec. nov.

Pileus 1.5-3.5 cm latus, explanatus, in medio umbilicatus, haud umbonatus, siccus, haud hygrophanus, omnino albo-pruinatus, pallide ochraceo vel flavo-ochraceo, concentrice zonatus. Lamellae tenues, confertae, decurrentes, pallide ochraceae deinde roseo-salmonatae. Stipes 1.5-3 x 0.2-0.3 cm, cylindraceo sub-bulbosus, siccus, concolor pileo, sub-levis vel fibrillosus, ad basim radiculis albidis praedito. Caro parce conspicua, albida; odor debilis, sapor farinosus. Sporarum pulvis rosea. Sporae 4.5-5.2 x 3.7-4.5 um, cyanophilae, subglobosae, angulosae. Basidia 19-28 x 6-7 um, tetraspora, clavata. Lamellarum trama leviter irregularis. Cystidia nulla. Pilei cutis ex hyphis radialibus, cylindraceis, 3-5.2 um latis, constituta; pigmento intraparietalis. Fibulae nullae.

Habitat: ad terram, interdum subcaespitosa, prope Juniperus phoenicea L., in sabulosis locis. Mediterranea. Autumno. Rara. Typus: central Sadinian, Marina di Arbus, 1.XII.1991, legit M. Contu (CAG 91/304, typus !).

Cap 1.5-3.5 cm broad, not very fleshy, flattened, usually depressed at centre with margin enrolled when young, without umbo; surface dry, not hygrophanous, not striate, entirely white-pruinose, often concentrically zonate, pale ocher to yellowish-ocher. Gills crowded, narrow, decurrent, pale ocher then pink. Stipe 1.5-3 x 0.2-0.3 cm, cylindrical with a sub-bulbose base, concolorous with the cap, smooth to fibrillose, at the base with white rhyzoids. Flesh thin, unchanging, whitish; smell not distincyive, taste strongly farinose. Spore-print clearly pink.

Spores 4.5-5.2 x 3.7-4.5 um, subhyaline, cyanophilous, subglobose, angular, with a large apiculus. Basidia 19-28 x 6-7 um, four-spored, clavate, without clamps. Hymenophoral trama slightly irregular. Cystidia of any kind not recovered. Pileal surface a cutis of radially arranged, 3-5.2 um wide, subcylindrical hyphae, with vacuolar and intraparietal pigmentation. Clamp connections absent.

Ecology and distribution: mediterranean, growing gregarious to subcaespitose in sandy soils, alwys under or near Juniperus phoenicea L. Late autumn. Very rare and known only from a single station, in central Sardinia.

Collections studied: Marina di Arbus (Central Sardinia), loc. Piscinas, in sand dunes near and under Juniperus phoenicea L. 1.XII.1991, legit M. Contu (CAG 91/304, typus !).

Discussion

On account of its feature (no cystidia nor clamps, central stipe, decurrent lamellae, etc.) Rhodocybe ochraceopallida has to be placed, according to Baroni (1981) in the section Decurrentes (Konr. & Maubl.) Sing. and seems to be closed especially to Rhodocybe popinalis (Fr.) Sing. and Rhodocybe parilis (Fr.) Sing. By the former, however, it differs in colours (without greysh shades), unchanging, not blackening context, a mild taste and finally by the smaller and only undulate spores. By the latter the most significant distinctive features are the colours (not greysh), spore-size (usually smaller and subglobose) and ecology [Rhodocybe parilis (Fr.) Sing. grows only in grasslands].

Between the other entities studied by Baroni (l.c.) and Noordeloos (1983) none show similarities.

Rhodocybe caelata (Fr.) R. Maire and Rhodocybe malençonii Pacioni et Lalli (= Clitopilus ammophilus Malençon) are also found in sand dunes but the former has pleurocystidia and the latter is even more different due to its grey-brownish colours, much bigger size, more elongate spores and a bitter taste.

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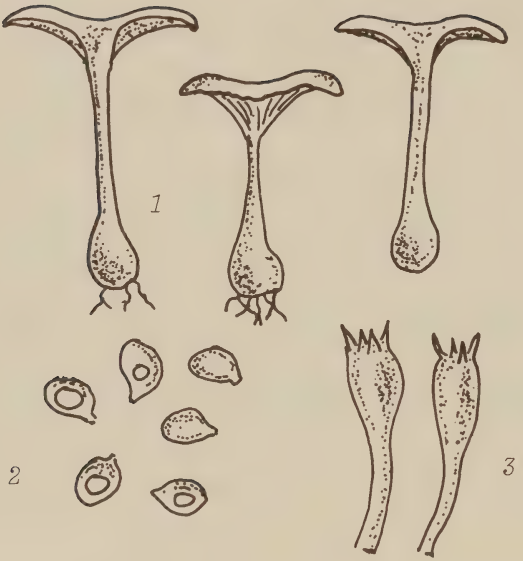

Rhodocybe ochraceopallida spec. nov.

1) carpophores and section – 2) spores –

3) basidia.

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A NEW SPECIES OF CHAETOPSINA FROM TROPICAL FOREST LITTER

Laura Zucconi and Angelo Rambelli

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Abstract

A new species of *Chaetopsina*, *C. acutispora*, from tropical forest litter, is herewith described and illustrated. Its morphological features have been observed by SEM.

The genus *Chaetopsina* was established by Rambelli (1956) with the type species *C. fulva* Rambelli and, for several years, it remained an unispecific genus. Starting from 1971 some new *Chaetopsina* species have been described: *C. ramifera* Matsushima (1971); *C. splendida* B. Sutton & Hodges (1976); *C. ivoriensis* Rambelli & Lunghini (1976); *C. virtuosa* Rambelli & Lunghini (1979); *C. romantica* Rambelli & Lunghini (1979), erroneously included by DiCosmo *et al.* (1983) in the genus *Chaetopsis* Greville (Rambelli, 1987); *C. auburnensis* Morgan-Jones (1979), whose inclusion in the genus is doubtful (Rambelli, 1987) and *C. ludoviciana* Crane & Schoknecht (1982) for which Kirk & Sutton (1985) proposed the new combination *Menisporopsis ludoviciana* (Crane & Schoknecht) Kirk & Sutton.

Some taxonomic disorder then arose by the almost simultaneous publication of several new *Chaetopsina* species and of papers on the generic limits of the genus (Samuels, 1985; Kirk, 1985; Kirk & Sutton, 1985; Kuthubutheen & Sutton, 1985; Kuthubutheen & Nawawi, 1987). The genus was reassessed by Rambelli (1987). He did not accept the yellow discoloration of the conidiophores in lactic acid as generic diagnostic character as proposed by Samuels (1985), and, consequently, the new genus *Kionochaeta* Kirk & Sutton (1985) introduced by the authors to accommodate those species characterized by dark brown dematiaceous rather than yellow discolouring conidiophores. Moreover, Rambelli (1987) did not accept to limit the genus to those species which are probable or verified anamorphs of *Nectria*, as suggested by Samuels (1985), and he considered that "different anamorph genera can be correlated to the same teleomorph genus, or that the same anamorph genus can be correlated to different teleomorphs". The author emphasized that an erroneous interpretation of the variation caused some misinterpretations and he suggested a rigorous application of the original diagnosis. Holubová-Jechová (1990) also pointed to the unnatural heterogeneity of this genus being caused by different concepts adopted by different authors for its delimitation.

More recently, Wingfield (1987) proposed the new species *C. illinii* (Crane) Wingfield, as a new combination for *Phialocephala illinii* Crane (1971), with a stipe occasionally branched and once or twice dichotomously forked at the apex. Finally, Merli *et al.* (1992) published the new species *C. nimbae* Rambelli on dead leaves of *Lophira alata* collected in Guinea Conacry (SW. Africa).

During mycological investigations carried out in the Tai National Park (Ivory Coast), a new interesting species, characterized by setiform conidiophores with lateral branches and production of phialoconidia, was found on leaf litter. For these characters we propose to include this fungus in the genus *Chaetopsina* as a new species.

Chaetopsina acutispora Zucconi & Rambelli, sp. nov. (Fig. 1).

Etym.: *acutus* (L.) = pointed and *spora* (L.) = spore; referring to the conidial shape.

Coloniae amphigenae, effusae, non circumscriptae, lucentes. Mycelium partim superficiale, partim immersum; mycelium superficiale ex hyphis dilute pigmentatis, ramosis, septatis, levibus compositum. Conidiophora macronematosa, mononematosa, setiformia, erecta, recta vel ad locos fertiles leviter curvata, septata, fulva, tenuitunicata et levia inferius, ab prima cellula ramigena crassitunicata et saepe verrucosa, obscuriora et crassius tunicata apicem versus, usque ad 350 µm longa et 5.0-8.0 µm crassa prope basim. Apparatus conidiogenus plerumque ex secunda cellula ortus, ex variis ramorum ordinibus compositus. Cellulae conidiogenae enteroblasticae, monophialidicae, discretae, determinatae, lageniformes, tenuitunicatae, subhyalinae, inferius verrucosae, collulis extensis et levibus et collaribus inflatis praeditae, 4.0-7.0 x 3.0-4.5 µm. Conidia aseptata, levia, hyalina, acerosa, saepe modice incurvata, utrimque acuminata, 6.0-9.0 x 1.5-2.5 µm, in capitulum mucosum circa fertilem partem aggregata.

Holotypus IMI 355489, in foliis emortuis *Cuerveae macrophyllae* (Vahl) R. Wilczek ex N. Hallé, Tai, in Ora Eboris, leg. A. Rambelli, 11 March 1992.

Colonies amphigenous, effuse, non-circumscribed, glistening. Mycelium partly superficial, partly immersed; superficial mycelium composed of very pale brown, branched, septate, smooth hyphae. Conidiophores macronematous, mononematous, setiform, erect, straight or slightly curved at the side of conidium production, septate, yellow long dash-yellowish brown, thin-walled and smooth near the base, thick-walled and often verrucose from the first cell that gives rise to lateral branches, darker and ticker towards the apex, up to 350 µm long and 5.0-8.0 µm wide near the base. Base enlarged, not delimited by a septum. Conidiogenous apparatus normally originating from the second cell of the conidiophore stipe, but produced also from the successive cells of the conidiophore stipe, composed of different orders of yellowish branches. Conidiogenous cells enteroblastic, monophialidic, discrete, determinate, lageniform, thin-walled, subhyaline, verrucose near the base, with an extended and smooth neck and an enlarged collarette, 4.0-7.0 x 3.0-4.5 µm. Conidia aseptate, smooth, hyaline, acerose, often slightly curved, with pointed ends, 6.0-9.0 x 1.5-2.5 µm, aggregated in slimy masses around the fertile part of the conidiophore.

Cultures from the holotype have been deposited in IMI (IMI 355489) and CBS (CBS 667.92).

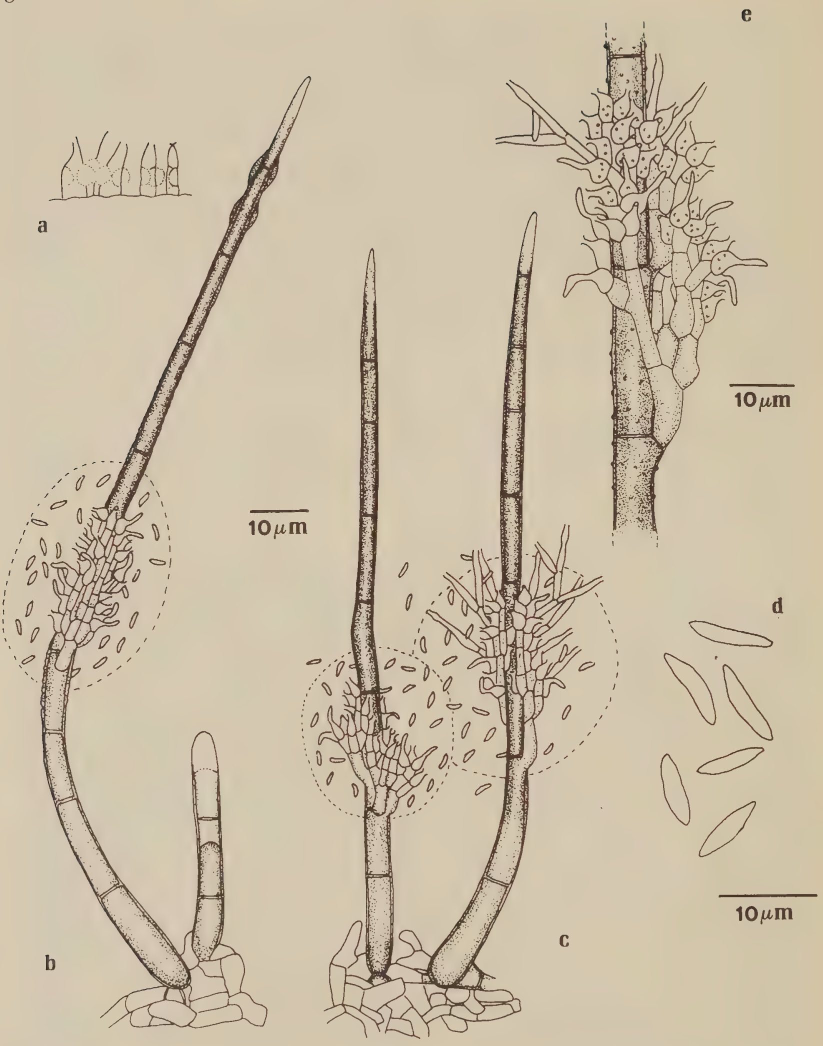
a
b
c
d
e
10 μm
10 μm
10 μm

Fig. 1 - *Chaetopsina acutispora*: a: habit sketch; b: conidiophore from leaf in pure culture; c: conidiophores from natural substratum; d: conidia; e: conidiogenous apparatus.

The main distinctive characteristic of this species is the presence of acuminate conidia. This feature was so far only reported for *C. virtuosa* Rambelli & Lunghini (1979) from which our species differs in smaller dimensions, having shorter conidia (20.5-34.5 µm long in *C. virtuosa*), and in shape, the conidia being aseptate and acerose and not 0-1 septate and falcate.

The description given here is derived from the material in nature. Growth in pure culture was tested on PDA, where fructification is improved by adding sterilized leaf fragments to the medium. In this case conidiophores generally reached larger dimensions (up to 450 µm long and 6.5-11.0 µm wide near the base) and the lateral branches were mostly originated from the third, fourth or, more rarely, fifth cell of the conidiophore. Moreover, they sometimes formed nodose swellings, seen rarely in nature; these structures, also observed in *Circinotrichum britannicum* P.M. Kirk (1981) and in some strains of *C. fulva* (Rambelli *et al.*, 1991), may be caused by nutritional factors.

It is interesting to observe the occasional presence, mainly on natural substratum, of exceptionally extended conidiogenous cells, produced from abnormal elongated branches, protruding beyond the conidial mass (Fig. 2a). This may be the result of a proliferation process. This phenomenon may contribute to additional improvement of the conidium production.

SEM observation shows a random orientation of the conidiogenous cells with verrucose surface bases and smooth necks (Fig. 2c). The conidia are smooth, they appear almost pointed at both ends, only slightly tapered at the base (Fig. 2b). The collarettes of the phialide are enlarged and often torn (Fig. 2d). This species does not show an asymmetric shape of the collarette as seen in *C. fulva* Rambelli (Onofri & Zucconi, 1991); for this reason the conidia do not remain in parallel packages, as in the type species of the genus and as reported for *C. ivoriensis* (Rambelli & Lunghini, 1976), but form a conspicuous slimy mass around the fertile area of the conidiophore. The slimy coat disappears in lactic acid and it is not preserved during SEM preparation.

Acknowledgements

The Authors wish to thank Prof. S. Onofri for his criticism and Prof. W. Gams for critically reviewing the manuscript. They also wish to

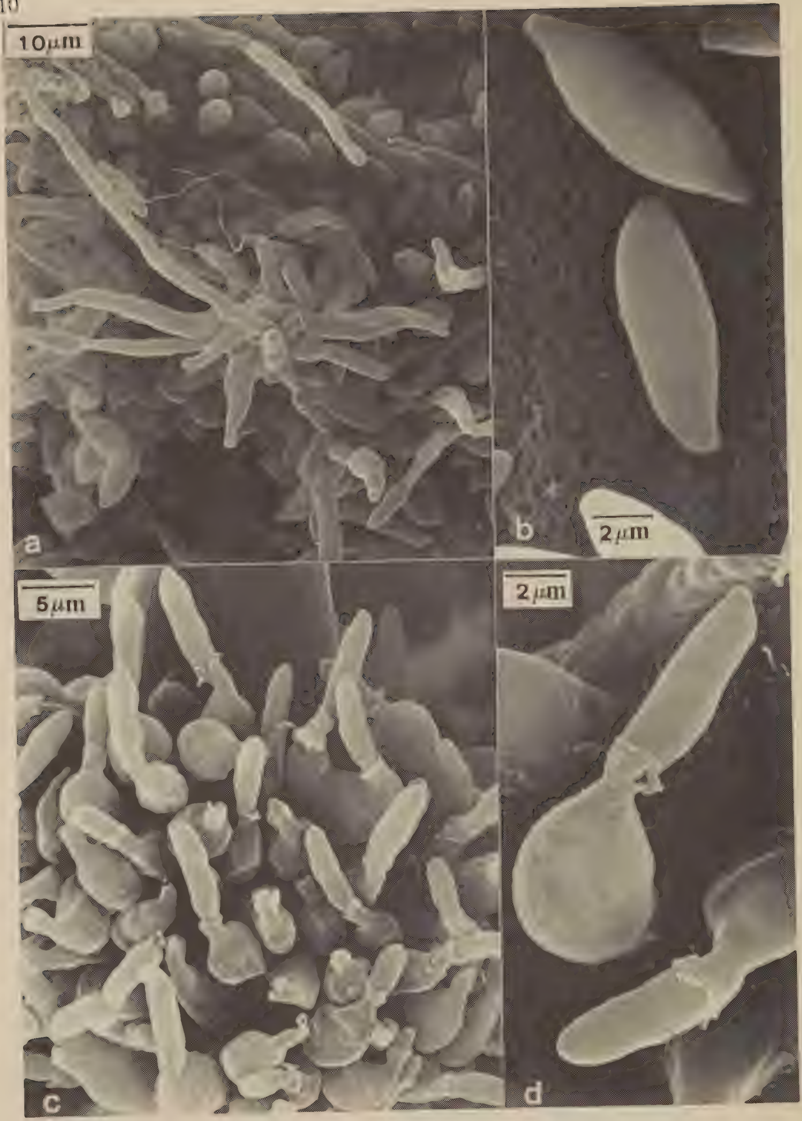

Fig. 2 - *Chaetopsina acutispora*: a: elongated conidiogenous cells from natural substratum; b: conidia with a slightly tapered base from leaf in pure culture; c: conidiogenous cells at random oriented from leaf in pure culture; d: flaring collarettes of phialides producing conidia from leaf in pure culture.

thank Prof. L. Ake Assi, Abidjan, Ivory Coast, for the identification of the natural substratum.

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CALVATIELLA CHOW, A SYNONYM FOR *BOVISTELLA* MORGAN

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Summary

After a search of numerous collections belonging to the genus *Bovistella* Morgan, 1892, and to the original description for the genus *Calvatiella* Chow, 1936, it is concluded that both represent the same taxonomic concept. Thus, *Calvatiella* is congeneric with *Bovistella*.
Bovistella melanospora Kreisel is proposed as a new species. A key to five recognized species of *Bovistella* and a list of 34 excluded species are added.

INTRODUCTION

In 1892 MORGAN described the genus *Bovistella* to include those *Lycoperdaceae* with pyriform, ovoid or globose fruitbody, somewhat stipitate or radicant. Dehiscent by irregular breaking down of peridium, like in *Calvatia,* and with sterile base of cellular nature. Capillitial threads of *Bovista* type and spores globose, pedicellate, smooth or finely asperulate. The "Ainsworth & Bisby's dictionary of the Fungi" (HAWKSWORTH & *al.*, 1983) recognized three species of *Bovistella* in the world. In 1969 KREISEL published a key to separate the species from Nepal Himalaya.

On the other hand, the genus *Calvatiella* was proposed by CHOW in 1936, to separate two species with the following features, according to the original description: "Exoperidium corticatum, tenue, persistens vel evanescens; endoperidium membranaceum, papyraceum, superne irregulariter rimoso-dehiscens; gleba floccoso-pulverulenta, basi sterili persistente instructa; hyphae capillitii discretae, in ramos tenuiores attenuatos divisae; sporae globosae, leves vel asperulo-verrucosae, caudatae vel ecaudatae, coloratae. Dignoscitur peridio *Calvatiae* et capillitio *Bovistae* et *Bovistellae.*"

CHOW (1936) included here two species: *Calvatiella sinensis* Chow and *C. lioui* Chow.

In the course of our research, within the *Gasteromycetes,* we have examined material from different countries, including the types of most *Bovis-*

tella species, but not the two types of *Calvatiella,* which disappeared during the Second World War (Bo Liu, pers. comm.). At a first look, some specimens collected in Spain fit apparently well within the description given by Chow *(l.c.)* for *Calvatiella sinensis.* Later studies suggested a re-evaluation of the taxonomic concept of this genus, taking in mind the difficulty of its delimitation and segregation from *Bovistella* Morgan. On the other hand, several of the collections observed did show a calvatioid mode of dehiscensce in *Bovistella.* In other words, the mode of dehiscence in *Bovistella* is rather variable, and the calvatioid mode of dehiscence in *Calvatiella* fits within this variability.

Material and methods

Most of the collections studied here were obtained by the own authors in mycological expeditions and the rest borrowed from herbaria, as indicated in each case. After a previous examination under the light microscope, the Spanish collections were observed in a Jeol JSM-T 330 A SEM, following the usual techniques in this field. German and Nepalese collections have been studied with a TESLA Brno BS 300 SEM.

Collections studied

Bovistella melanospora Kreisel, **sp. nova**

Carposomata globosa, 5.5 cm diam.; basis plicata cuneiformis terram mineralicam conglobans. Exoperidium albidum, nigrescens, in vertice areolatum et in squamas parvas diffractum, basim versus crustaceum; exostratum cellulis isodiametricis, 15-30 µm diam., compositum. Endoperidium papyraceum, chalceum, dextrinoideum, in vertice ore stellato-lobato 25-30 mm amplo dehiscens. Gleba brunneonigra, pulverulenta. Subgleba bene manifesta, parvocellulosa, violaceogrisea, pseudodiaphragmate patiniformiter concavato glebam versus delineata.

Sporae globosae, 3.5-5.1 µm diam., punctatae vel verruculosae, in cumulo subnigrae, pedicellis fulvis, rectis, ad 15 µm longis praeditae. Capillitium rufum obscurum, gracillimum, pariete subcrassi, poris magnis circularibus, polygonalibus vel stellatis perforatum, non septatum, modo generis Bovista e trunco capitali 6.2-8.5 µm crasso dichotome ramificatum. Sporae, pedicelli capillitiumque acyanophili. Paracapillitium deest.

Habitat in fruticetis nanis montium altorum (4100-4200 m.s.m.). Locus typicus; Nepal, Himalaya centralis,m in area Langtang, loco Langshisa, Big Rocks, leg. *J. Poelt,* 15-XI-1986, N 86-F 31 (Holotypus GZU).

Fruitbody (exsiccate) 55 mm diam., globose with plicate conical base, connected with a small globe of mineral soil, without pseudorhiza-like formation (fig. 1). Exoperidium whitish, blackening, areolate-squamulose on the apex, otherwise crustaceous; exoperidium composed of mostly isodia-

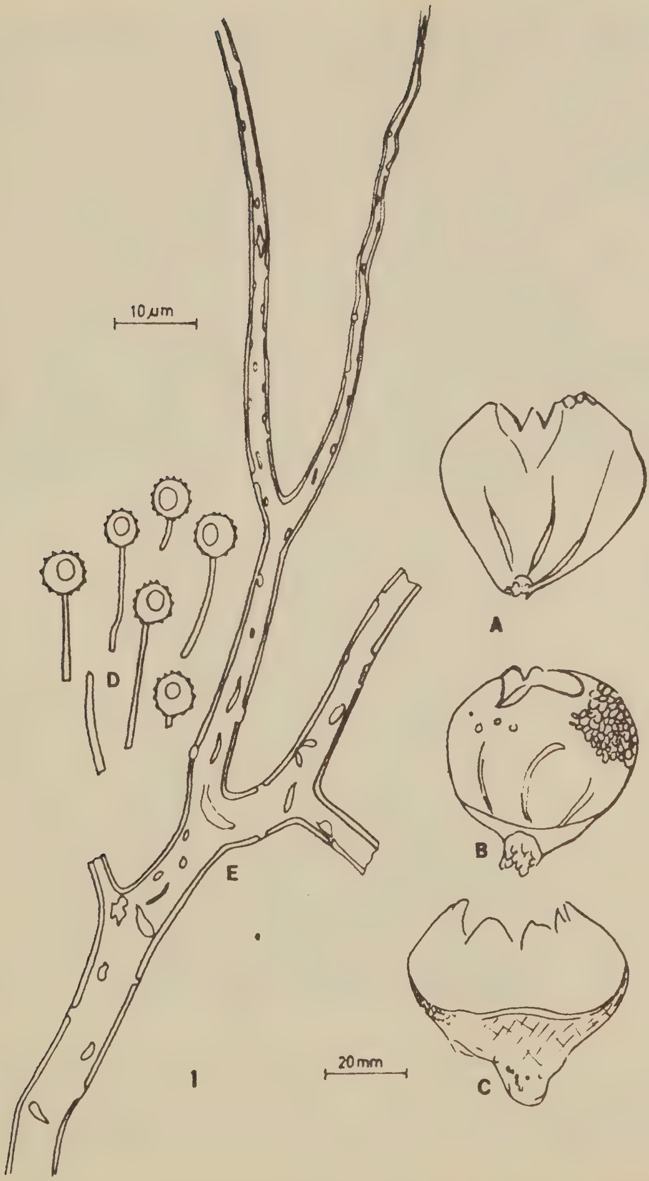
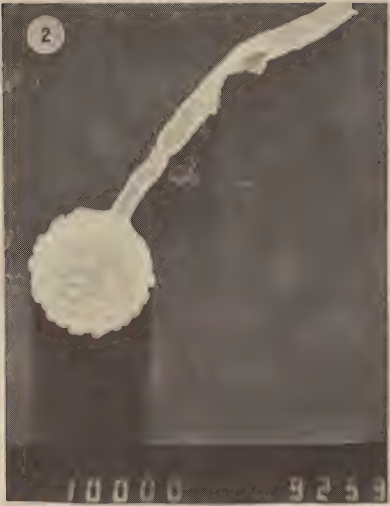
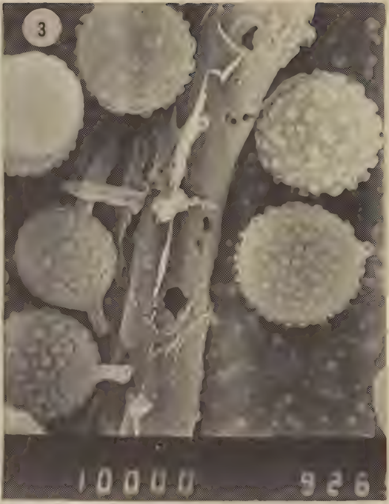


Fig. 1.—*Bovistella melanospora* Kreisel. Diagrammatic representation of the main characters of this taxon: fruitbody (a, b, c); pedicellated spores (d) and pitted dichotomous capillitium (e). Typus.





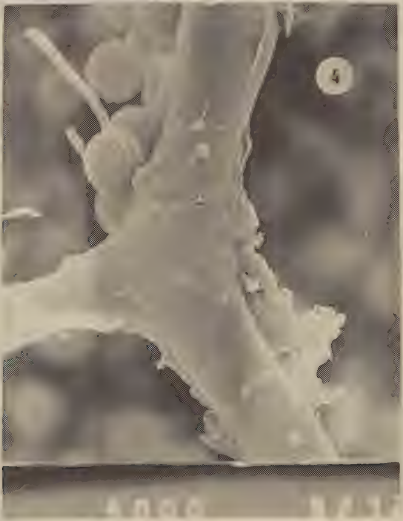


Fig. 2.—*Bovistella melanospora* Kreisel. Spore as seen in the SEM, showing a verruculose ornamentation and a long pedicel. Typus. Fig. 3.—*Bovistella melanospora* Kreisel. SEM photograph showing typical ornamented spores and pores in the capillitium of different shape, circular to polygonal or irregular ones. Typus. Fig. 4.—*Bovistella poeltii* Kreisel. Electron micrograph showing verruculose spores with long pedicels and capillitium without pits. Typus.

metric, subglobose, subpyriform or ellipsoid, hyalie cells of 15-30 µm diam. Endoperidium papery, bronze-brown (remembering *Bovista nigrescens* Pers.), somewhat shining at the base; showing an irregular stellate-lobate aperture at the apex; dextrinoid. Gleba nearly black, powdery, without pseudocolumella. Subgleba well developed, soft, cellular with small cells, violaceous grey, with a depressed, patelliform pseudodiaphragm.

Spores dark brown (spore print nearly black), globose, punctate to verruculose, 3.5-5.1 µm diam., pedicellate; pedicels straight, rufous (2.6-)10-15 µm long, 0.8-1.2 µm thick, not acuminate (fig. 2). Capillitium of *Bovista* type, very fragile, dark reddish-brown, rather thick-walled, aseptate, with frequent very large circular to irregular-polygonal or even stellate pits of 0.8-2.7 µm diam. (fig. 3); dichotomous branching, main truncs 6.2-8.5 µm thick. Spores, pedicels and capillitium acyanophilous. No paracapillitium present.

Holotypus: Nepal, Central Himalaya, Langtang area, Langshisa, Big Rocks, in low scrub, 4100-4200 m.s.m., 15-XI-1986, leg. *J. Poelt,* N 86-F 31 (GZU).

Bovistella japonica C. G. Lloyd (1906)

Fruitbody with a well developed pseudorhiza. Exoperidium tomentose with indistinct spines, making up pyramidal structures. Capillitium without pores but with main trunks densely ramifies and long acuminate branches. Spores verruculose with pedicels 5-13 µm long.

JAPAN: Sapporo, leg. *K. Miyabe,* BPI (LLO) 30748, Holotypus.
USA: Ohio, Preston, leg. *A. P. & L. V. Morgan* 1893, NY herbarium, L. M. Underwood (as *Bovistella ohiensis).*

Bovistella poeltii Kreisel (1969)

Fruitbody without pseudorhiza. Exoperidium forming polygonal areoles on the apex of the carpophore. Capillitium without pores; spores verruculose and pedicellated (fig. 4).

NEPAL: Mahalangur, Himalaya, Khumbu, near Phalong Karpoo, above Pheriche, meadow, leg. *J. Poelt,* IX-1962, no. 612, M, holotypus. Vorhimalaya, Okhaldunga, around Thodung, *Abies-Rhododendron* forest, ca. 3000 m.s.m., leg. *J. Poelt,* IX-1962, no. 62, M.

Bovistella sinensis C. G. Lloyd (1922)

Fruitbody globose up to 6 cm diam., with a well developed pseudorhiza (fig. 5). Exoperidium areolate-squamose on the apex, otherwise verrucose-spinulose. Capillitium with circular to elliptic pores; spores shortly pedicellated (fig. 5).

CHINA: No further data, leg. *O. Mattirolo,* BPI (LLO 30747), Holotypus.
NEPAL: Khumbu Himalaya, Chukung, beneath Nuptse, very dry short meadow, *Leontopodium,* 5146 m.s.m., leg. *E. Albertshofer,* 26-X-1971, M.

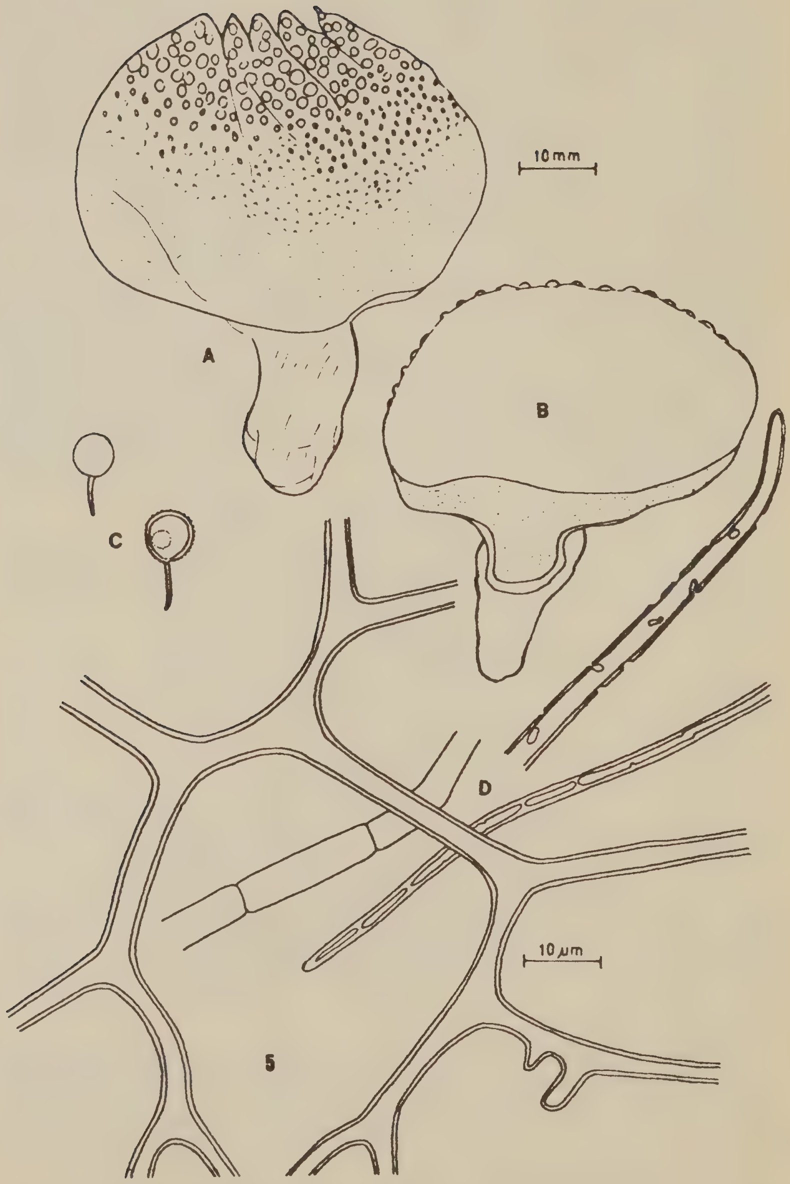

10 mm
A
B
C
D
10 µm
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Fig. 5.—*Bovistella sinensis* C. G. Lloyd. Diagrammatic representation of main characters: fruitbody (a, b), spores (c) and capillitium (d). Nepal.

Bovistella radicata (Dur. & Mont.) Pat. (1937), Bull. Soc. mycol. France 53: 102 (1937)

Fruitbody globose, very variable in size, from 2-25 cm diam., normally provided with a pseudorhiza, but not always (fig. 6). Exoperidium tomentose to furfuraceous with indistinct pyramidal structures. Capillitium with circular to polygonal pores (fig. 7), and spores globose to ovoid, smooth to verruculose (figs. 8-9), with pedicels 2-15 µm long (fig. 10).

ALGERIA: D. Retelle, *C. Montagne,* PC herbarium, Holotypus. Bon-Charen, leg. *R. Maire,* 11-XII-1929, PRM 487532.

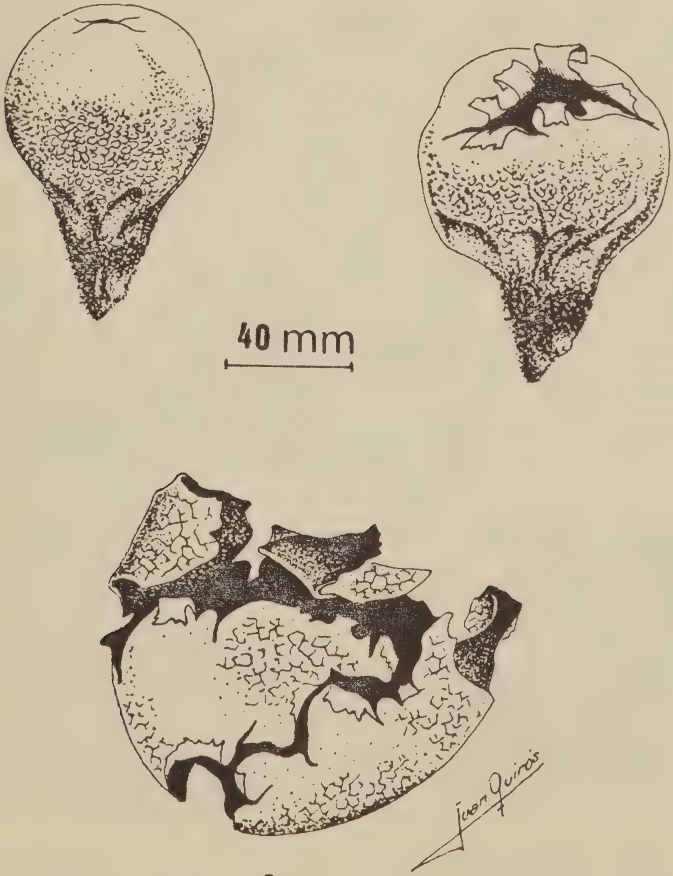

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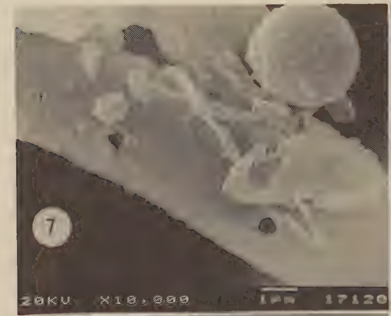
Fig. 6.—*Bovistella radicata* (Dur. & Mont.) Pat. Fruitbody showing typical pseudorhiza and apical irregular dehiscence.

Bulgaria: Bačkovo, in rimis saxorum supra Monastyr, leg. *M. Deyl*, VII-1936, PMR 485542.

Yugoslavia: Macedonia, in fruticetis prope Katlanovská Baňa procul Skoplja, ad terram alt. ca. 530 m.s.m., leg. *A. Pilát*, VII-1937, PRM 489235.

Spain: Huelva, Parque Nacional de Doñana, in littoral sand dunes, leg. *F. D. Calonge*, 14-IV-1978, MA-Fungi, duplicate in herb. H. Kreisel. Ávila, Pico Barril, *Thymus*, *Cistus*, *Lavandula*, in granite soil, leg. *J. M. Santos*, 3-VI-1988, MA-Fungi. Madrid, road Miraflores-Canencia, *Quercus pyrenaica*, in granite soil, leg. *F. D. Calonge*, 17-VII-1977, MA-Fungi. Cáceres, Navalmoral de la Mata, in sandy soil,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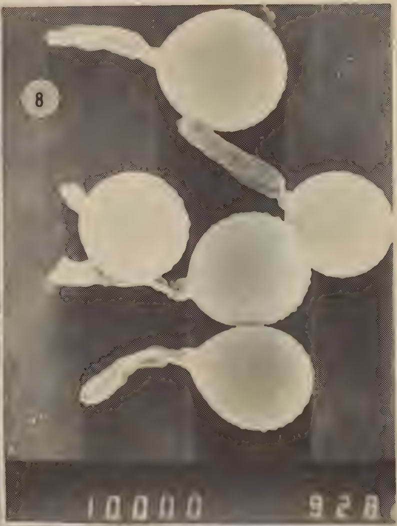
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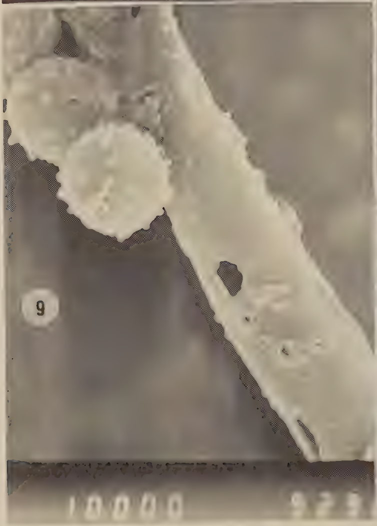
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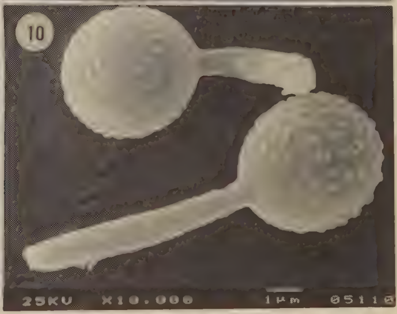
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Fig. 7.—*Bovistella radicata*. Verruculose spores and pitted capillitium as seen in the SEM. Spain, National Park of Doñana. Fig. 8.—*Bovistella radicata*. Punctate spores of immature specimen, Germany, Premnitz. Fig. 9.—*Bovistella radicata*. Verrucose spores and capillitium with elongated pits, as seen in the SEM. USA, Oklahoma. Fig. 10.—*Bovistella radicata*. Verruculose spores with long pedicels as seen in the SEM. Spain, Ávila.

leg. *A. Sánchez,* 10-XI-1990, MA-Fungi. Lugo, Furelos, lawn, leg. *M. Castro & L. Freire,* 23-V-1982, LOU. Barcelona, El Bruc (as *Lycoperdon radicatum),* in sandy soil under *Pinus halepensis,* leg. *M. A. Maublanc,* 23-X-1935, not seen.

ENGLAND: Near White Lodge, Richmond Park, on sandy soil, leg. *D. A. Reid,* 9-VI-1952, LIVU myc. 2036 (as *Bovista* sp.).

GERMANY: Berlin, Glienicker Park near Nikolskoe, leg. *R. Bickerich,* IX-1975, herb. H. Kreisel. Königs Wusterhausen, in Reserve Dubrow at lake Hölzerner See, light dry *Quercus* forest with *Cladonia,* on sandy soil, leg. *K. Klose & H. Holdack,* 12-VIII-1958, herb. H. Kreisel. Premnitz, loco Dachsberg, *Pinus sylvestris, Quercus robur, Betula, Calluna,* on sandy soil, leg. *H. Otte,* 1958, herb. H. Kreisel. Greifswald, near Steffenshagen, dry sandy hill with *Nardus stricta, Deschampsia flexuosa,* leg. *H. Kreisel & H. Holdack,* 9-VI-1958, herb. H. Kreisel. Ueckermúnde, near Altwarp, light *Quercus-Pinus* forest on sand dunes, leg. *H. Kreisel,* VI-1983, herb. H. Kreisel. Dessau, near Kapen, leg. *Zoerner,* 1964, herb. H. Kreisel.

POLAND: Cladow, forest near Marienspring, leg. *P. Sydow,* VII-1888, Mycotheca Marchica 2112 (as *Lycoperdon hirtum).*

USA: Oklahoma, misit *G. S. Bulmer,* 1961, herb. H. Kreisel. *C. G. Lloyd*, PC (as "*Bovistella ohiensis* Morgan, not the usual form"). Michigan, Saw Mill, Riverdale, Gratiot Co., cespitose along sides of small trench draining sawdust pile, leg. *V. Potter,* 4-XI-1948, no. 6784, herb. H. Kreisel (misit A. H. Smith). Missouri, prope Perryville, ad terram, leg. *C. H. Demetrio,* 1885, GFW, Rabenhorst & Winter, Fungi Europaei no. 3536 (as *Mycenastrum ohiense* Ellis & Morgan). Indiana, leg. *A. R. Bechtel,* NCU. Florida, Gainesville, pond "A", hammock, leg. *F. W. Walker,* 8-VIII-1924, NCU (as *Bovistella ohiensis).* Florida, Gainesville, leg. *E. West,* 21-X-1936, NCU. Florida, Marion Co., high oak hammock, leg. *J. N. Couch,* 26-VI-1924, NCU 7276 (as *Calvatia craniformis).* Georgia, Columbus Co., misit G. C. Rebell 1943, NCU. Unknown provenience, possibly from Portugal, leg. *C. Torrend,* NCU, Fungi selecti exsiccati no. 771 (as *Bovista radicata).*

PORTUGAL: Ribatejo, Pancas, Reserva Natural do Estuario do Tejo, leg. *M. Correia,* 20-I-1983, LISU. Estremadura, Pinhal de Cotovia, leg. *M. Correia,* 30-X-1984, LISU. Estremadura, Cascais, leg. *P. Coutinho,* no. 181, LISU. Estremadura, Vale de Rosal, leg. *C. Torrend,* XI-1907, COI. Beira Baixa, San Fiel, leg. *C. Torrend,* XI-1903, COI.

KEY TO THE GENUS *BOVISTELLA* MORGAN
= *Calvatiella* Chow

Type species: **Mycenastrum ohiense** Ellis & Morgan, J. Mycol. 1: 89 (1885)
= *Lycoperdon radicatum* Dur. & Mont., in Durieu, Fl. d'Algerie 1: 383 (1846)

A. Capillitium not pitted; main trunks densely ramified with acuminate branches.

B. Base of fruitbody with a distinct, strong, up to 8 mm thick pseudorhiza. Exoperidium tomentose with indistinct pyramides of composed spines. Pedicels 5-13 µm long . . . . **B. japonica** C. G. Lloyd 1906
Japan (type), USA (Ohio)

B'. Base of fruitbody without pseudorhiza. Exoperidium areolate-polygonal on the apex of fruitbody. Pedicels 6.5-14 µm long . . . **B. poeltii** Kreisel 1969
Nepal (Himalaya, ca. 3000 m.s.m., type)

A'. Capillitium with small to large pits, at least in the thinner branches.

C. Spores with yellowish brown, 10-15 µm long pedicels. Spore print nearly black. Exoperidium areolate-polygonal. Capillitium with very large, often polygonal pits. Without pseudorhiza ... **B. melanospora** Kreisel, **sp. nov.**
Nepal (Himalaya, 4100-4200 m.s.m., type)

C'. Spores with hyaline, short to long pedicels. Spore print olivaceous-brown to amber. Pits elliptic to circular.

D. Exoperidium areolate-squamose on the apex of fruitbody, otherwise verrucose-spinulose. Spores under light microscope punctate to verruculose; pedicels 4.5-8.5 µm long. Fruitbody 50-60 mm large. Pseudorhiza present . . . . **B. sinensis** C. G. Lloyd 1922
Nepal (Himalaya, 5146 m.s.m.), temperate China (type)

D'. Exoperidium tomentose to furfuraceous with indistinct pyramides of composed spines. Spores, under light microscope, smooth to weakly punctate (may appear verruculose under SEM); pedicels 2-15 µm long. Pseudorhiza, in general, distinct, strong, 4-15 mm thick, but may be indistinct or absent in northern collections. Fruitbody 2-25 cm large . . . . **B. radicata** (Dur. & Mont.) Pat. 1899
≡ *Lycoperdon radicatum* Dur. & Mont. 1846
Algeria, La Calle (type)
= *B. ammophila* (Lév.) Pat. & Hariot 1902
B. ammophila Lév. 1850
France (no material available of type)
= *B. ohiensis* (Ellis & Morgan) Morgan 1892
= *Mycenastrum ohiense* Ellis & Morgan 1885
USA, Ohio (type)
= *Calvatiella sinensis* Chow 1936
China (type not seen)
= *B. karstenii* Nyberg 1945, nom. illeg. (no Latin diagnosis)
Finland, Mustiala (type not seen)

SPECIES EXCLUDENDAE (COMPILED BY H. KREISEL)

Bovistella aspera (Lév. 1846) C. G. Lloyd 1905 from Chile
= *Bovista aspera* Lév.

Bovistella atrobrunnea Zeller 1948 from USA, Michigan
= *Lycoperdon* sp., teste A. H. Smith

Bovistella australiana C. G. Lloyd 1905 from Australia
= *Lycoperdon glabrescens* Berk., teste G. H. Cunningham

Bovistella bovistoides (Cooke & Massee 1888) C. G. Lloyd 1906 from India
= *Bovista bovistoides* (Cooke & Massee) Ahmad

Bovistella citrina (Berk. & Br. 1873) C. G. Lloyd 1919 from Sri Lanka
= *Bovista citrina* (Berk. & Br.) Bottomley

Bovistella conspurcata (Berk. & Br. 1873) Petch 1919 from Sri Lanka
= *Lycoperdon* sp.

Bovistella coprophila (Cooke & Massee ex Cooke 1892) G. H. Cunningham 1926 from Australia
= *Bovista coprophila* (Cooke & Massee) G. H. Cunningham

Bovistella cuprica C. G. Lloyd 1915 from New Zealand
= *Lycoperdon* sp.

Bovistella davisii C. G. Lloyd 1906 from USA, Massachusetts
= *Bovista dominicensis* (Massee) Kreisel

Bovistella dealbata C. G. Lloyd 1902 from USA, Washington
= *Bovista leucoderma* Kreisel

Bovistella dominicensis (Massee 1889) C. G. Lloyd 1906 from Dominica
= *Bovista dominicensis* (Massee) Kreisel

Bovistella echinata (Pers. 1792) P. Coutinho 1919 from Germany
= *Lycoperdon echinatum* Pers.: Pers.

Bovistella echinella (Pat. 1891) C. G. Lloyd 1906 from Ecuador
= *Bovista echinella* Pat.

Bovistella flaccida C. G. Lloyd 1924 from USA, California
= *Bovista flaccida* (C. G. Lloyd) Kreisel

Bovistella flaccida C. G. Lloyd after 1905 ? from Japan
= *Lycoperdon* sp.

Bovistella floridensis Peck 1909 from USA, Florida
= species dubia, type not seen

Bovistella gemmatum C. G. Lloyd, publ. ? from USA, Wisconsin
= *Lycoperdon* cf. *miyabei* (C. G. Lloyd) Ito

Bovistella glabrescens (Berk. 1860) C. G. Lloyd 1905 from Tasmania
= *Lycoperdon glabrescens* Berk., teste Demoulin

Bovistella gunnii (Berk. 1860) C. G. Lloyd 1905 from Tasmania
= *Bovista gunnii* (Berk.) Kreisel

Bovistella henningsii C. G. Lloyd 1906 fron India, Himalaya
= *Bovista bovistoides* (Cooke & Massee) Ahmad, teste Kreisel

Bovistella humidicola Bowerman in Bowerman & Groves 1962 from Canada, Manitoba
= *Bovista paludosa* Lév., teste Kreisel

Bovistella longi-pedicellata Teng 1962 from China
= *Bovista longissima* Kreisel 1969, which would be a younger synonym

Bovistella miyabei C. G. Lloyd 1906 from Japan
= *Lycoperdon miyabei* (C. G. Lloyd) Ito

Bovistella nigrica C. G. Lloyd 1922 from New Zealand
= *Lycoperdon scabrum* (C. G. Lloyd) G. H. Cunn., teste Cunningham

Bovistella oblongispora C. G. Lloyd 1917 from South Africa
= *Bovista oblongispora* (C. G. Lloyd) Bottomley, teste Kreisel

Bovistella paludosa (Lév. 1846) C. G. Lloyd 1902 from France
= *Bovista paludosa* Lév.

Bovistella pedicellata (Peck 1874) C. G. Lloyd 1906 from USA
= *Lycoperdon caudatum* Schroet.
= *Lycoperdon pedicellatum* Peck, non Batsch

Bovistella pusilla C. G. Lloyd 1910 from Australia
= *Bovista coprophila* (Cooke & Massee) G. H. Cunn., teste Kreisel

Bovistella rosea C. G. Lloyd 1906 from Australia
= *Lycoperdon glabrescens* Berk., teste Cunningham

Bovistella scabra C. G. Lloyd 1906 from Australia
= *Lycoperdon scabrum* (C. G. Lloyd) G. H. Cunn.

Bovistella trachyspora C. G. Lloyd 1906 from India, Himalaya
= *Bovista trachyspora* (C. G. Lloyd) Kreisel

Bovistella verrucosa G. H. Cunn. 1925 from Australia
= *Bovista verrucosa* (G. H. Cunn.) G. H. Cunn.

Bovistella yasudae C. G. Lloyd 1922 from Japan
= *Lycoperdon yasudae* (C. G. Lloyd) Kreisel

Bovistella yunnanensis (Pat. 1890) C. G. Lloyd 1906 from China
= *Bovista citrina* (Berk. & Br.) Bottomley, teste Kreisel

Discussion

The description of the genus *Calvatiella* by Chow in 1936 shows a series of features which remind us those published for *Bovistella* by Morgan in 1892.

Unfortunately, the type material of *Calvatiella* is not available since it was detroyed during the Second World War. Nevertheless, Chow's description and illustrations are clear enough to take a decision on this subject. After studying many collections of this complex group, we believe that there is not sufficient base to maintain the genus *Calvatiella* as independent from *Bovistella*. Thus, we propose *Calvatiella* as a synonym of *Bovistella*, and precisely the type species *Calvatiella sinensis* Chow is considered synonym of *Bovistella radicata* (Dur. & Mont.) Pat., while the other species, *C. lioui* Chow, is synonymised with *Handkea utriformis* (Bull.: Pers.) Kreisel [= *Calvatia utriformis* (Bull.: Pers.) Jaap].

According to our genus concept, *Bovistella* actually comprises five species, with a critical position for *B. japonica* C. G. Lloyd, which is very close to *B. radicata,* being the only difference the capillitium, without pits in the former and pitted in the latter. In fact, *B. japonica* could be considered as a variety of *B. radicata,* but we prefer to keep it as an autonomous species at present.

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TAXONOMICAL STUDIES ON USTILAGINALES. X.*

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ABSTRACT

NEW GENUS proposed: Heterodoassansia K. Vánky (type H. morotiana).

NEW SPECIES proposed: Sporisorium dimeriae-ornithopodae K. Vánky & C. Menge (type on Dimeria ornithopoda). – Sporisorium pseudechinolaenae K. Vánky & C. Menge (type on Pseudechinolaena polystachya). – Sporisorium tripogonis R. V. Gandhe, N. D. Sharma & K. Vánky (type on Tripogon jacquemontii). – Tilletia savilei R. V. Gandhe & K. Vánky (type on Tripogon jacquemontii). – Tolyposporium rhynchosporae-cephalotis K. & T. Vánky (type on Rhynchospora cephalotes). NEW NAME proposed: Tolyposporium fischeri K. Vánky (type on Rhynchospora plumosa).

NEW COMBINATIONS proposed: Conidiosporomyces verruculosus (Wakfield) K. Vánky, based on Ustilago verruculosa (type on Setaria aurea). – Heterodoassansia hottoniae (Rostrup) K. Vánky, based on Entyloma hottoniae (type on Hottonia palustris). – Heterodoassansia morotiana (Zundel) K. Vánky, based on Doassansia morotiana (type on Baldellia ranunculoides). – Heterodoassansia punctiformis (Winter) Vánky, based on Doassansia punctiformis (type on Lythrum hyssopifolia). – Heterodoassansia putkonenii (Liro) K. Vánky, based on Doassansia putkonenii (type on Ranunculus paucistamineus). – Neovossia opaca (H. Sydow) K. Vánky, based on Tilletia opaca (type on Spinifex squarrosus). – Sporisorium cornutum (H. & P. Sydow & Butler) K. Vánky, based on Ustilago cornuta (type on Ophiurus corymbosus). – Sporisorium culmiperdum (Schröter) K. Vánky, based on Ustilago culmiperda (type on Andropogon bicornis). – Sporisorium dimeriae (Patil & Thirumalachar) K. Vánky, based on Sorosporium dimeriae (type on Dimeria gracilis). – Sporisorium holwayi (G. P. Clinton & Zundel) K. Vánky, based on Sphacelotheca holwayi (type on Andropogon bicornis). – Sporisorium lophopogonis (Thirumalachar & Pavgi) K. Vánky, based on Sorosporium lophopogonis (type on Lophopogon tridentatus). – Sporisorium sacciolepidis (Thirumalachar) K. Vánky, based on Sphacelotheca sacciolepidis (type on Sacciolepis indica). – Tolyposporium rhynchosporae (P. Hennings) K. Vánky, based on Sorosporium rhynchosporae (type on Rhynchospora glauca). – Urocystis narcissi (González Fragoso) K. Vánky, based on Urocystis colchici f. narcissi (type on Narcissus sp.).

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*Studies in Heterobasidiomycetes, part 95

SYNONYMS: Bauhinus Moore is a synonym of Microbotryum Léveillé. Both Ustilago holubii H. Sydow (type on Echinochloa holubii) and Sphacelotheca almorae A. Krishna & R. A. Singh (type on Echinochloa frumentacea) are synonyms of Ustilago trichophora (Link) Körnicke (type on Echinochloa colonum).

EXCLUDED SPECIES: Ustilago mirabilis Sorokin (type on Phragmites australis) is Arthrinium phaeospermum (Hyphomycetes).

A NEW GENUS OF SMUT FUNGI

There is a group of smut fungi, parasitizing aquatic or paludal plants, characterized by permanent spore balls embedded in the host tissue. The spore balls are composed of nearly colourless spores, sterile cells and/or hyphae. The arrangement and relationship of these elements in the spore balls is used for generic delimitation (Setchell, 1891, Vánky, 1981, 1985). To date the following genera are recognized (Vánky, 1987): Burillia Setchell, Doassansia Cornu, Doassansiopsis (Setchell) Dietel, Nannfeldtiomyces K. Vánky, Narasimhania Thirumalachar & Pavgi emend K. Vánky, Pseudodoassansia (Setchell) K. Vánky, and Tracya H. & P. Sydow.

The type of Doassansia, D. alismatis (Nees) Cornu, is characterized by spore balls composed of a central mass of spores surrounded by a more or less evident cortex of homogenous, smooth sterile cells. The cortex of sterile cells of the holotype of Doassansia morotiana Zundel is not homogenous. It is composed of an external layer of small, often radially flattened, smooth cells, and an internal layer of larger, usually subcubical, irregular to radially elongated cells. The inner surface (toward the empty lumen) of these cells is finely echinulate or provided with nail-headed warts up to 1 µm high. On the basis of the heterogenity of the cortical sterile cells a new genus is proposed:

Heterodoassansia K. Vánky, gen. nov.

Heterodoassansia gen. nov. generi Doassansia Cornu similis, sed ab eo heterogenitate corticis glomeruli sporarum distincta. Cortex ille in Heterodoassansia ex cellulis sterilibus externis, parvis, levibus et cellulis interioribus item sterilibus magnis, inanibus, superficie interna ornatis compositus. Haec duo genera cellularum sterilium similiter vel in uno vel in pluribus stratis disposita, stratum cellularum externarum parvarum forte interruptum.

Typus generis Heterodoassansia morotiana (Zundel) K. Vánky, comb. nov. Basionym: Doassansia morotiana Zundel, The Ustilaginales of the World, 1953, p. 229 (Doassansia intermedia Morot, 1895, non Setchell, 1894). Type on Echinodorus ranunculoides (L.) Engelm. (= Baldellia ranunculoides (L.) Parl.; Alismataceae), France, Maine-et-Loire, Cholet, VIII.1894, C. Morot (PC!).

Heterodoassansia is similar to Doassansia Cornu, from which it differs by the heterogenity of the cortex of spore balls. The cortex in Heterodoassansia is composed of external, small, smooth sterile cells and internal, larger, empty sterile cells with ornamented inner surface (fig. 2). Both kinds of sterile cells may be arranged in one or in several layers, or the layer of external, small cells may be incomplete.

Further species which belong to Heterodoassansia are:

Heterodoassansia hottoniae (Rostrup) K. Vánky, comb. nov.

Basionym: Entyloma hottoniae Rostrup, in Thümen, Mycotheca universalis no. 2222, 1888. Type on Hottonia palustris L., Denmark, Funen, Skårup, VI.1883, E. Rostrup & C. J. Johanson (HUV 511!).

Heterodoassansia punctiformis (Winter) K. Vánky, comb. nov.

Basionym: Doassansia punctiformis Winter, Revue Mycologique, Toulouse, 8:207, 1886. Type on Lythrum hyssopifolia L., Australia, Victoria, near Melbourne, 20.X.1885, coll. Reader (BPI 178786!, PAD!).

Heterodoassansia putkonenii (Liro) K. Vánky, comb. nov.

Basionym: Doassansia putkonenii Liro, Luonnon Tutkija 24:72, 1920, emend Liro, Ann. Acad. Sci. Fenn., Ser. A, 42(1):214, 1938. Type on Ranunculus paucistamineus Tausch, Finland, Åland, Eckerö island, Storby, 22.VII.1919, T. Putkonen (H!).

Spore ball forming smuts on Rhynchospora (Cyperaceae).

In connection with a Tolyposporium, collected in Costa Rica on Rhynchospora cephalotes, I checked the smuts on Rhynchospora possessing spore balls. The Costa Rican specimen differs from these smuts and it is proposed as a new species:

Tolyposporium rhynchosporae-cephalotis K. et T. Vánky, sp. nov.

Typus in matrice Rhynchospora cephalotes (L.) Vahl (det. J. Gómez-Laurito), Costa Rica, Prov. Alajuela, 1,5 km S.E. Los Chiles, pr. pag. San Jerónimo, alt. ca. 50 m.s.m., 24.III.1991, leg. T. & K. Vánky. Holotypus in Herbario Ustil. Vánky (HUV 15199); isotypi in Vánky, Ustilaginales exsiccata no. 862.

Sori (fig. 1) in floribus, ad superficiem partium floris internarum (praesertim ad stamina, glumae setaeque intactae) massam nigram, primo conglutinatam, serius granulosam-pulveream glomerulorum sporarum per glumas perfecte obtectam formantes. Infectio systemica; nullae florum in eadem inflorescentia intactae. Glomeruli sporarum (fig. 3, 4) irregulares, sphaerioidei, ovoidei vel elongati, 16–30(–36) x 25–40(–50) µm, nigrobrunnei, e sporis (1–)4–25(–35?) satis firmiter conglutinatis compositi. Sporae subglobosae, ellipsoideae vel irregulariter subpolyangulares, latere libero rotundatae, raro subcuneiformes, 9–12(–13.5) x 12–16(–17.5) µm, nigrobrunneae sed satis perlucidae, superficie libera dense, minute usque aspere, plane, irregulariter verrucosae, verrucis saepe partim confluentibus.

Sori (fig. 1) in the flowers, on the surface of internal floral parts (especially around the stamens, glumes and bristles remain intact) forming a black, first agglutinated, later granular-powdery mass of spore balls completely concealed by the glumes. Infection systemic; all flowers of an inflorescence are affected. Spore balls (figs. 4, 5) irregular, spherical, ovoid or elongated, 16–30(–36) x 25–40(–50) µm, blackish-brown, composed of (1–)4–25(–35?) rather firmly agglutinated spores. Spores subglobose, ellipsoidal or subpolyhedrally irregular with rounded free side, rarely subcuneiform, 9–12(–13.5) x 12–16(–17.5) µm, blackish-brown but rather transparent, free surface densely provided with fine to coarse, irregular, often partly confluent warts.

For two other species of this group a new combination and a new name are proposed:

Tolyposporium rhynchosporae (P. Hennings) K. Vánky, comb. nov.

Basionym: Sorosporium rhynchosporae P. Hennings, Hedwigia 35:222, 1896. Type on Rhynchospora glauca Vahl (as "Rhynchospora exaltata Clark"), Brasil, Rio de Janeiro, VII.1887, E. Ule 1614 (HUV 1703!).

Sori in the flowers, concealed by the glumes, containing a black, granular-powdery mass of spore balls. Spore balls (fig. 3) subglobose, ellipsoidal or somewhat irregular, (20–)25–40 x (25–)30–45(–55) µm, dark reddish- to blackish-brown, opaque, composed of (6–)10–30(–50 or more?), firmly agglutinated spores. Spores subcuneiform to semiglobosely or subpolyhedrally irregular, 8–12 x 12–19 µm, dark reddish-brown, prominently verrucose on free surface, smooth on contact sides.

Tolyposporium fischeri K. Vánky, nom. nov.

Thecaphora rhynchosporae G. W. Fischer, Research Studies of the State College of Washington 20:5, 1952. Type on Rhynchospora plumosa Ell., USA, Miss., Coopolis, 15.VI.1898, coll. M. S. Tracy (Herb. S. M. Tracy no. 5225, NY!) non Tolyposporium rhynchosporae (P. Henn.) K. Vánky.

Sori on the surface of internal floral parts, naked, black, granular, concealed by the glumes. Spore balls firm, variable in shape and size, 15–35 x 16–45 µm, reddish-brown, composed of 2–20(–25?) spores or frequently spores single. Spores subglobose, cuneiform, hemispherical, elongated or irregular, 8–13 x 9.5–16(–20) µm, dark reddish-brown, free surface in LM apparently smooth to very finely punctate-verruculose, in SEM finely and densely verruculose, warts often confluent in smaller or larger irregular groups.

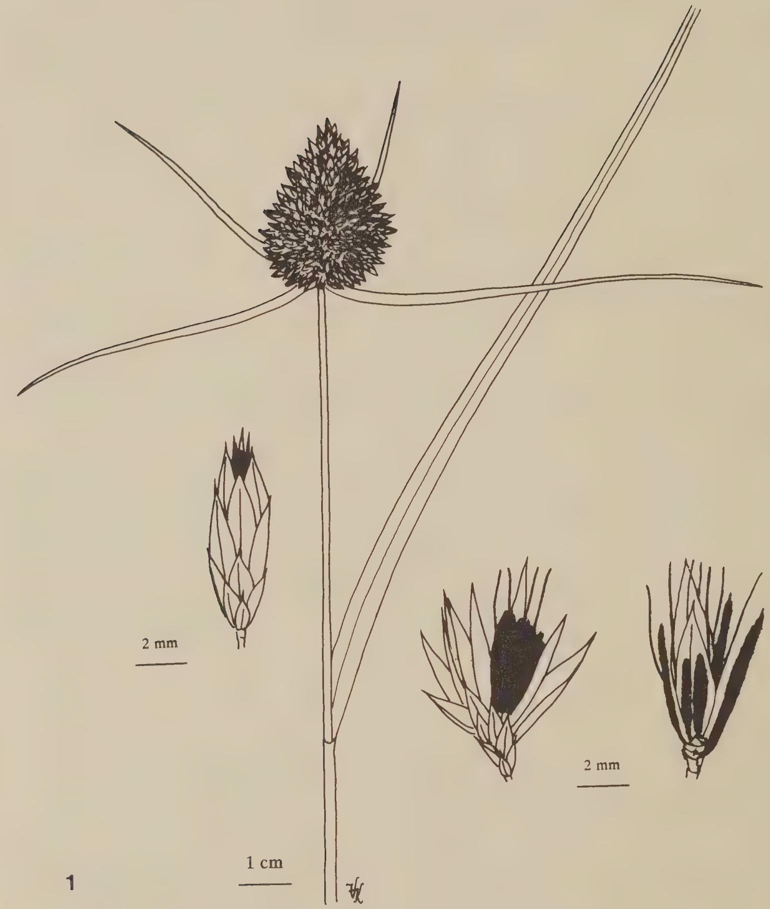

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Fig. 1. Tolyposporium rhynchosporae-cephalotis on Rhynchospora cephalotes (type). In two of the three enlarged spikelets the glumes are partly removed to show the intact glumes and bristles and the black, agglutinated spore masses around the stamens.

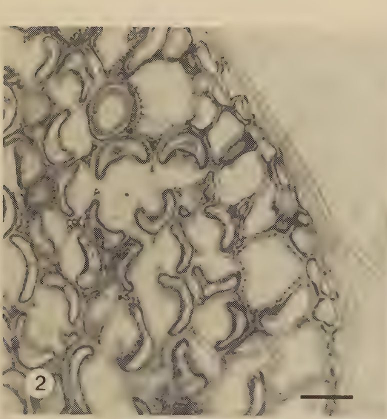
Fig. 2. Part of a sectioned spore ball of Heterodoassansia morotiana (type), showing the small, external, smooth sterile cells, the internal, larger, empty sterile cells with ornamented inner surface, and the central mass of spores (partly collapsed).

Fig. 3. Spore balls of Tolyposporium rhynchosporae (type) in LM.

Figs. 4, 5. Spore balls of Tolyposporium rhynchosporae-cephalotis (type) in LM and in SEM.

Figs. 6, 7. Spore balls, spores and groups of sterile cells of Sporisorium pseudechinolaenae (type) in LM and in SEM.

(Bars of figs. 2–7 = 10 µm)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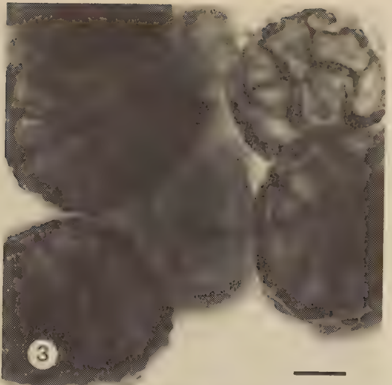
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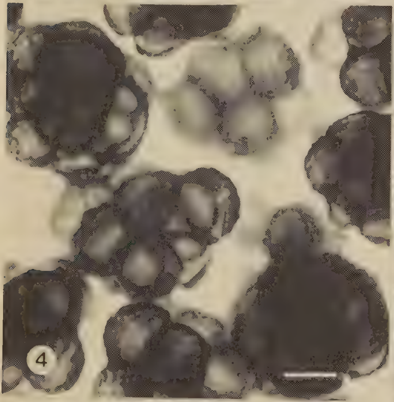
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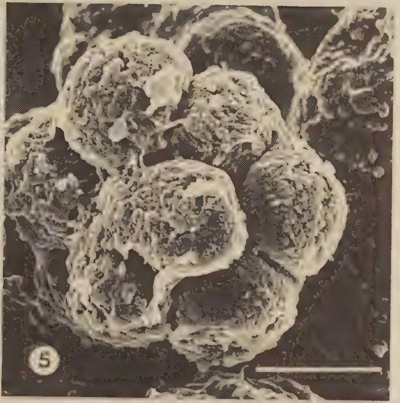
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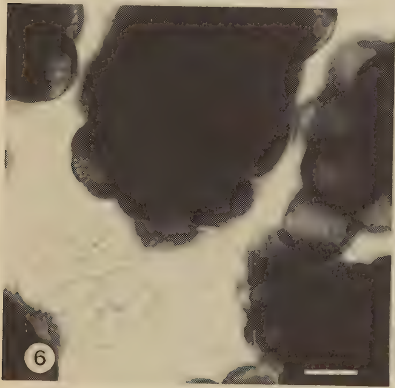
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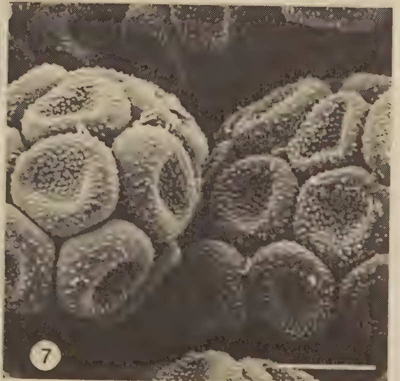
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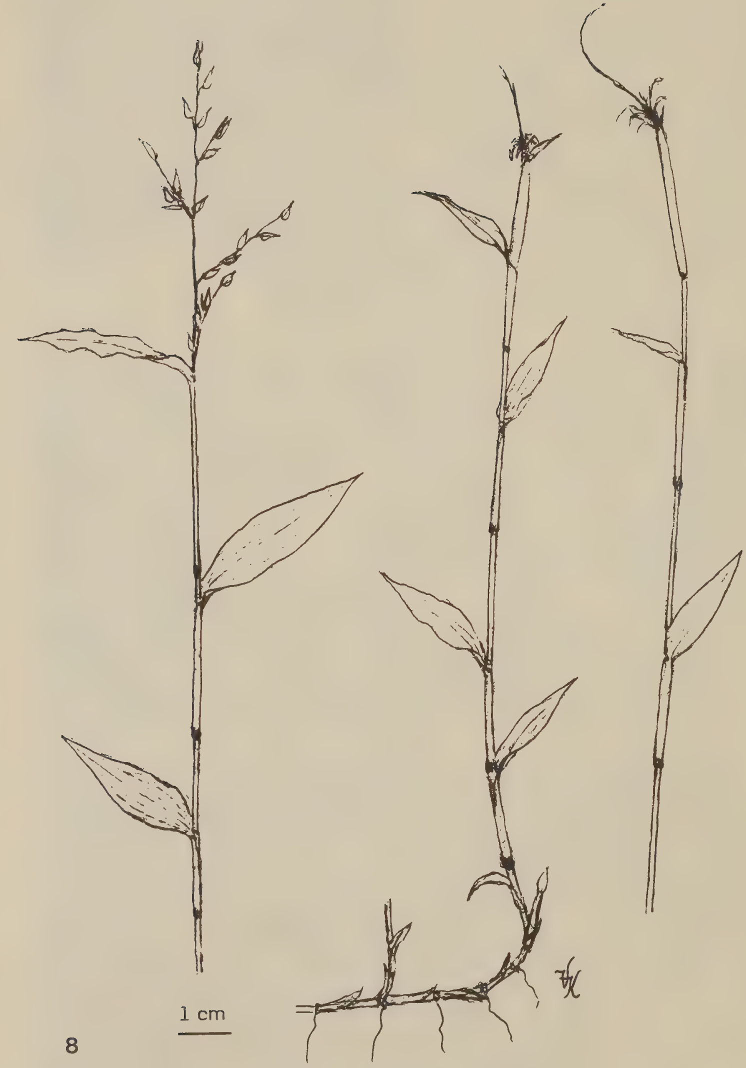

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Fig. 8. *Sporisorium pseudechinolaenae* on *Pseudechinolaena polystachya* (type). A healthy and two diseased plants. To remark that nearly the whole sorus is enchased in the uppermost leaf sheath; only the distal part of the lacerated peridium and the flagelliform columella protrude.

Key to the spore ball forming smuts on Rhynchospora.

1. Sori covered, in scattered, hypertrophied ovaries. Spore balls composed of spores and sterile cells 2
– Sori naked, in all flowers. Spore balls composed of spores only 3
2. Sori 5–15 mm, spore balls 75–350 µm long .... Testicularia cyperi
– Sori 3–7 mm, spore balls 45–115 µm long .... Testicularia minor
3. Spores apparently smooth. Balls of 1–20(–25?) spores .... Tol. fischeri
– Spores evidently ornamented. Balls of up to 35–50 spores 4
4. Spore balls irregular, mainly 25–40 µm long, composed of (1–)4–25 (–35?) subpolyhedral-hemispherical spores . . . Tol. rhynchosporae-cephalotis
– Spore balls more regular, mainly 30–45 µm long, composed of (6–)10–30 (–50?), mainly subcuneiform spores .... Tol. rhynchosporae

NEW SPECIES PROPOSED

Sporisorium pseudechinolaenae K. Vánky et C. Menge, sp. nov.

Typus in matrice Pseudechinolaena polystachya (Kunth) Stapf (Gramineae; examin. H. Scholz), Indonesia, Bali, ca. 44 km N.W. Denpasar, inter pagg. Antosari et Pupuan, pr. Bilimbing, alt. ca. 500 m.s.m., 9.IV.1992, leg. C. Menge & K. Vánky. Holotypus in Herbario Ustil. Vánky (HUV 15387); isotypi in Vánky, Ustilaginales exsiccata no. 853.

Sori (fig. 8) in tota inflorescentia, cylindracei, 2–5 cm longi, cca. 2 mm lati, initio cooperti peridio origine fungoso, pallide brunneo, serius ab apice dehiscenti et massam granulosam-pulveream, nigram glomerulorum sporarum cum acervis cellularum sterilium mixtam et columellam centralem origine matricalem patefacienti. Sorus fere totaliter vagina folii supremi coopertus, solum pars distalis peridii plus-minus disintegri et pars distalis 5–30 mm longa columellae flagelliformis, non vel vix ramificatae prominentes. Glomeruli sporarum (fig. 6, 7) subglobosi, ellipsoidei, elongati vel forma irregulares, 25–50 x 28–65(–80) µm, rubrobrunnei, e sporis (5–)10–80(–pluribus?), satis laxe connexis compositi. Sporae (fig. 6, 7) subglobosae, ellipsoideae usque subpolyangulariter irregulares, 9,5–12(–13) x 11–16 µm, rubrobrunneae, pariete 0,5–1,5 µm crasso, ad superficiem liberam sporarum tenuiore, minute denseque echinulato, proptera in sectione transversali ad partem liberam sporarum minute serrulato. Occasione germinationis sporarum (fig. 18) basidia e 2(–4)-cellulis constructa basidiosporas laterales et terminales, ovoideas usque longe ellipsoidales, 1,5–3 x 5–30 µm producentia. Cellulae basidii in unitates 2-cellulares sese disiungentes. Et basidia et basidiosporae basidiosporas reliquas longas sporidiaque secundaria in sterigmatibus brevibus continenter producentes. Cellulae steriles (fig. 6) in acervis irregularibus vel in catenis dispositae, forma magnitudineque variae, ad unum vel duo latera compressae, ad latus liberum hemisphaericae vel elongatae, subtetrangulares, 5–8(–12) x 6,5–13(–15) µm, subhyalinae usque pallide flavotinctae, pariete cca. 1 µm crasso, levi.

Sori (fig. 8) in the whole inflorescence, cylindrical, 2–5 cm long, c. 2 mm wide, first covered by a light brown, fungal peridium which disintegrates from its apex revealing the black, granular-powdery mass of spore balls mixed with groups of sterile cells and a central columella of host origin. Most of the sorus is encased in the uppermost leaf sheath. Only the distal part of the more or less disintegrated peridium and a 5–30 mm long distal part of the flagelliform, not or only poorly ramified columella protrude. Spore balls (figs. 6, 7) subglobose, ellipsoidal, elongated to somewhat irregular, 25–50 x 28–65(–80) µm, reddish-brown, composed of (5–)10–80(–more?), rather loosely connected spores. Spores (figs. 6, 7) subglobose, ellipsoidal to subpolyhedrally irregular, 9.5–12(–13) x 11–16 µm, reddish-brown; wall 0.5–1.5 µm thick, thinner on the free(!) surface of the spores, finely, densely echinulate causing the free part of the spore to appear finely serrulate in profile view. Spore germination (on water-agar, in 3 days, at 25 C^{0}; fig. 18) results in 2(–4)-celled basidia producing lateral and terminal, ovoid to long ellipsoidal basidiospores, 1.5–3 x 5–30 µm. Basidial cells separate easily into 2-celled units. Both separated basidia and basidiospores continue to produce long basidiospores and secondary sporidia on short sterigmata. Sterile cells (fig. 6) in irregular groups or chains, variable in form and size, flattened on one or two sides, hemispherical on their free side, or elongated, subtetrangular, 5–8(–12) x 6.5–13(–15) µm, subhyaline to pale yellow tinted, wall c. 1 µm thick, smooth.

Two new smuts on Tripogon (Gramineae).

Two smut fungi on Tripogon were collected and treated by Gandhe (1978) in his typewritten doctoral thesis as Ustilago tripogonis Gandhe and Tilletia savilensis Gandhe (invalidly published; Article 29 of the ICBN). Recently, rich material of these two smuts was collected and studied, and are described here as:

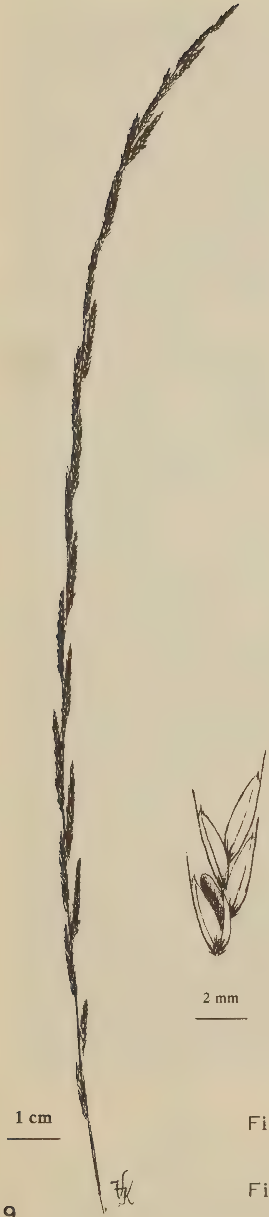
Sporisorium tripogonis R. V. Gandhe, N. D. Sharma et K. Vánky, sp. nov.
Typus in matrice Tripogon jacquemontii Stapf, India, Madhya Pradesh, 25 km E.N.E. Jabalpur, prope Water Reserve, alt. 500 m.s.m., 10.X.1992, leg. N. D. Sharma, S. R. Singh, M. B. Nagar, R. P. Mishra, C. Menge & K. Vánky. Holotypus in Herbario Ustilag. Vánky (HUV 15424), isotypi in Vánky, Ustilaginales exsiccata no. 857.

Sori (fig. 9) in floribus dispersis, glumis absconditi, ellipsoidei, 1 x 2–2,5 mm, membrana tenui, brunnescenti, origine matricali fungosaque obtecti, mature massam obscure brunneam, granulosam-pulveream, laxam glomerulorum sporarum, mixtam cum acervulis cellularum sterilium atque columellam brevem, centralem, origine matricalem ostendentes. Glomeruli sporarum (fig. 11, 12) irregulares, elongati, 50–130 µm longi, e sporis multis, faciliter separabilibus compositi. Sporae (fig. 11, 12) globosae, ovoideae usque subpolyangulariter irregulares, 8–11 x 8,5–13 µm mediocriter rubrobrunneae, pariete cca. 0,8 µm crasso, minutissime denseque punctato, sub SEM irregulariter verruculoso, saepe verruculis duobus vel nonnullis partim confluentibus. Cellulae steriles (fig. 11) subglobosae, ovoideae subpolyangulariter irregulares usque elongatae, plerumque minores quam sporae, 4–10(–14) µm longae, subhyalinae, interioribus homogeneae, pariete tenui (cca. 0,5 µm), levi. Decursu germinationis (fig. 19) sporae basidium septatum et ad septa basidiosporas ovoideas vel fusiformes producentes.

Sori (fig. 9) in scattered flowers, hidden by the glumes, ellipsoid, 1 x 2–2.5 mm, covered by a thin, brownish membrane of host and fungus origin which ruptures at maturity disclosing a dark brown, granular-powdery mass of loose spore balls mixed with groups of sterile cells and a short, central columella of host origin. Spore balls (figs. 11, 12) irregular, elongated, 50–130 µm long, composed of many easily separating spores. Spores (figs. 11, 12) globose, ovoid to subpolyhedrally irregular, 8–11 x 8.5–13 µm, medium reddish-brown; wall c. 0.8 µm thick, very finely and densely punctate, under SEM irregularly verruculose, often two or several warts partly confluent. Sterile cells (fig. 11) subglobose, ovoid, subpolyhedrally irregular to elongate, usually smaller than the spores, 4–10(–14) µm long, subhyaline with thin (c. 0.5 µm), smooth wall and homogenous content. Spore germination (in tap water; Gandhe, 1978:39; fig. 19) results in septate basidium producing ovoid or spindle-shaped basidiospores at the septa.

Gandhe (1978:39) reported this species also on Tripogon lisboae Stapf (India, M. P., Khandala, 5.VII.1973), and I found it in New Delhi, on Tripogon bromoides Roem. & Schult., under the name of "Tolyposporium tripogonae Yadav ined.", collected in India, M. S., Kolhapur, Panhala, 10.XI.1987, S. R. Yadav (HCIO!).

Tilletia savilei R. V. Gandhe et K. Vánky, sp. nov.
Typus in matrice Tripogon jacquemontii Stapf, India, Maharashtra State, Pune, University campus, 20.X.1992, leg. K. & R. V. Gandhe, C. Menge & K. Vánky. Holotypus in Herbario Ustilag. Vánky (HUV 15425), isotypi in Vánky, Ustilaginales exsiccata no. 859 (unacum Sporisorium tripogonis).



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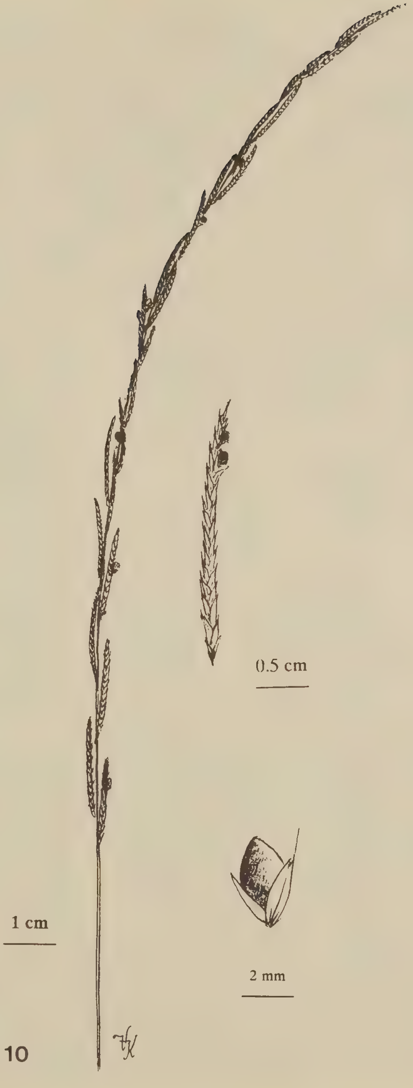

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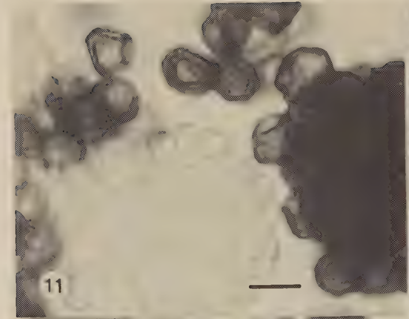
Fig. 9. Sporisorium tripogonis on Tripogon jacquemontii (type), a spike and some enlarged spikelets with a sorus.

Fig. 10. Tilletia savilei on Tripogon jacquemontii (type), a spike, a secund spike with two sori, and an enlarged spikelet with a sorus.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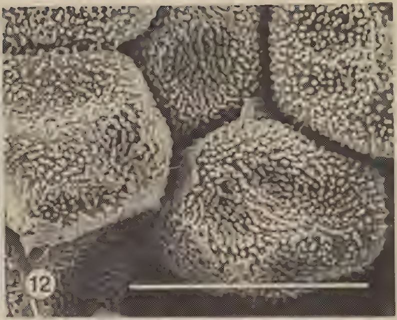
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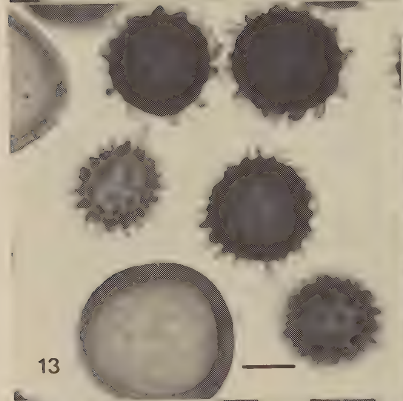
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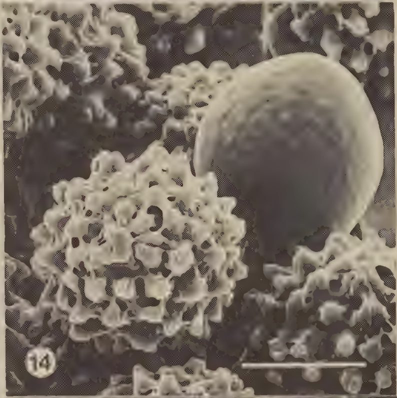
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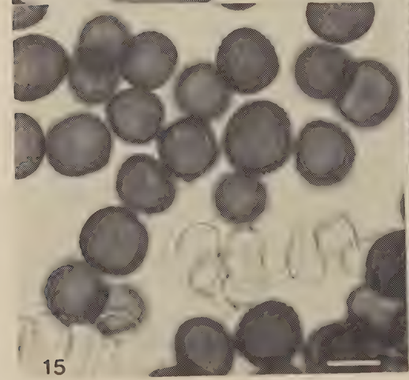
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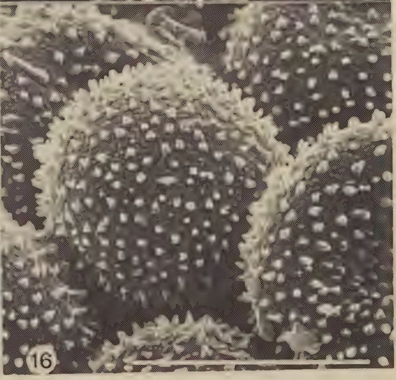
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Figs. 11, 12. Spores and sterile cells of *Sporisorium tripogonis* in LM and in SEM.
Figs. 13, 14. Spores and sterile cells? of *Tilletia savilei* (type) in LM and in SEM.
Figs. 15, 16. Spores and sterile cells of *Sporisorium dimeriae-ornithopodae* (type) in LM and in SEM.
(Bars = 10 µm)

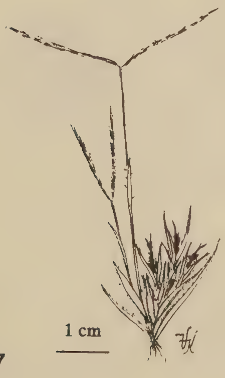
Sori (fig. 10) in ovariis dispersis, partim glumis absconditi, ovoidei, 1–1,5 x 2–3 mm, membrana initio viride, deinde brunnea, origine matricali cooperti. Sori maturi saepe a matrice disiungentes, vel membrana sori dehiscens massam sporarum nigram, semiagglutinatam cellulasque steriles ostendens. Sporae (fig. 13, 14) globosae forte ovoideae, 18–24 x 20–28 µm, pallide brunneae usque obscure nigrobrunneae, opacae, spinis duris, 2,5–3,5 µm altis, acutis vel subacutis ornatae. Cellulae steriles (fig. 13) globosae, ovoideae usque parum irregulares, 20–28 x 22–36 µm, subhyalinae usque pallide brunneae, interioribus granulosae, pariete levi, 2.5–4(–5) µm crasso. In decursu germinationis sporae (fig. 20) basidium aseptatum fasciculum terminalem 8–20 basidiosporarum filiformium, inter se non coniugentium producens.

Sori (fig. 10) in scattered ovaries, partly hidden by the glumes, ovoid, 1–1.5 x 2–3 mm, covered by a first green later brown membrane of host origin. Mature sori often fall off the plant or the sorus membrane may crack exposing the black, semiagglutinated mass of spores and sterile cells. Spores (figs. 13, 14) globose, subglobose, occasionally ovoid, 18–24 x 20–28 µm, light brown to opaque, dark blackish-brown, provided with coarse, 2.5–3.5 µm high, acute or subacute spines. Sterile cells (fig. 13) globose, ovoid to slightly irregular, 20–28 x 22–36 µm, subhyaline to light brown, with smooth, 2.5–4(–5) µm thick wall and granular content. Spore germination (Gandhe 1978:114; fig. 20) results in aseptate basidia bearing a terminal cluster of 8–20 filiform basidiospores which do not fuse.

The generic position of this species is uncertain. It possesses some of the characters of a Tilletia, some of those of a Neovossia (comp. Vánky & Bauer, 1992:434). A critical study of all these intermediate species is badly needed to elucidate the generic delimitation of Tilletia and Neovossia.

Sporisorium dimeriae-ornithopodae K. Vánky et C. Menge, sp. nov.
Typus in matrice Dimeria ornithopoda Trin. (Gramineae; det. S. Karthikeyan, BSI), India, Maharashtra State, Mahabaleshwar, alt. ca. 1310 m.s.m., 26.X.1992, leg. C. Menge & K. Vánky. Holotypus in Herbario Ustil. Vánky (HUV 15399); isotypi in BPI et in Vánky, Ustilaginales exsiccata no. 848.

Sori (fig. 17) in tota inflorescentia, lineares, cca. 10 mm longi, 1 mm lati, in statu juvenili vagina folii supremi inclusi, serius protrusi, cooperti a peridio origine fungoso, crasso, brunneo, mature ab apice dehiscenti et columellam centralem, longam, filiformem, saepe ramificatam, origine matricalem, deinde massam sporarum nigro-brunneam, semipulveream simul cum acervis stellularum sterilium patefacienti. Sporae (fig. 15, 16) immaturae in glomerulis laxis, serius singulares, globosae, subglobosae usque ovoideae, 9–13 x 10–14,5(–16) µm, atro-rubrobrunneae, pariete cca. 0,8 µm crasso, conspicue, dense echinulato, sub SEM inter spinas minute, dense verruculoso. Cellulae steriles (fig. 15) forma et magnitudine variae, subglobosae, semiglobosae, cuneiformes, subtetrangulares vel irregulares, 7–13 µm longae, subhyalinae, pariete 0.5–1 µm crasso, levi et continentia granulosae. Basidium septatum in decursu germinationis (fig. 21) basidiosporas laterales et terminales, elongatas, ellipsoidales, 1,5–2 x 5–10 µm producens. Post disjunctionem facilem cellularum basidii et basidiosporarum confectio sporidiorum continua.



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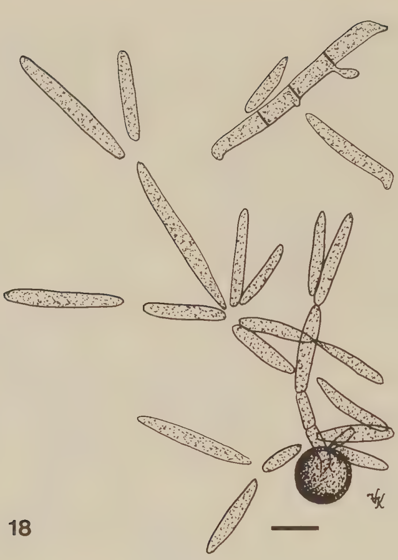
Sori (fig. 17) in the whole inflorescence, linear, c. 10 mm long, 1 mm wide, when young enchased in the uppermost leaf sheath, later protruding, covered by a thick, brown, fungal peridium which early dehisces from its apex disclosing a long, filiform, often branched, central columella of host origin and the blackish-brown, semipowdery mass of spores mixed with groups of sterile cells.



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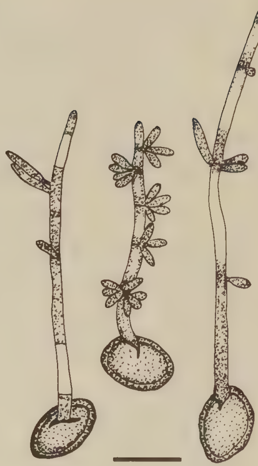

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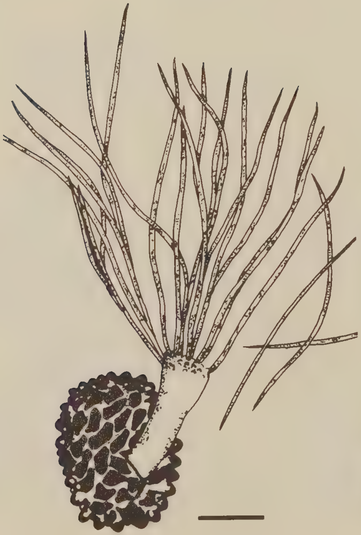

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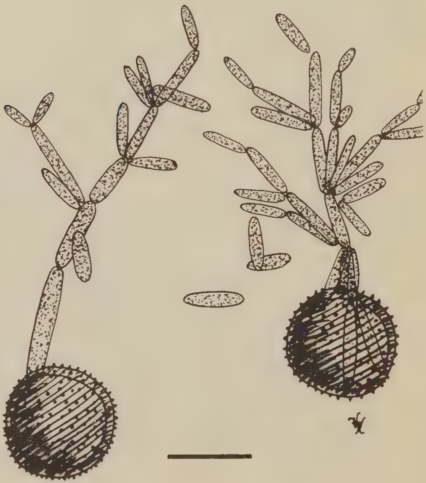

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Fig. 18. Spore germination of *Sporisorium pseudechinolaenae* (type).
Fig. 19. Spore germination of *Sporisorium tripogonis* (Gandhe, 1978, fig. 21).
Fig. 20. Spore germination of *Tilletia savilei* (Gandhe, 1978, fig. 246).
Fig. 21. Spore germination of *Sporisorium dimeriae-ornithopodae* (type).
(Bars = 10 μm)

Spores (figs. 15, 16) when young in loose spore balls, later single, globose, subglobose to ovoid, 9–13 x 10–14.5(–16) µm, dark reddish-brown; wall c. 0.8 µm thick, prominently, densely echinulate, in SEM between the spines finely and densely verruculose. Sterile cells (fig. 15) variable in form and size, subglobose, semiglobose, cuneiform, subrectangular or irregular, 7–13 µm long, subhyaline, with 0.5–1 µm thick, smooth wall and a granular content. Spore germination (on WA, after 2 weeks, at 29 C^{o}; fig. 21) results in septate basidium producing lateral and terminal, long, ellipsoidal basidiospores of 1.5–2 x 5–10 µm. Basidial cells and basidiospores separate easily and continue to produce new sporidia.

Sporisorium dimeriae-ornithopodae differs from Sporisorium dimeriae (Patil & Thirumalachar) K. Vánky, comb. nov. Basionym: Sorosporium dimeriae Patil & Thirumalachar, Sydowia 20:48, 1966(1968), type on Dimeria gracilis Nees. In this latter species the sori are in the ovaries, the spores measure 7–12 µm in diameter, the external spores of the spore balls are dark brown, verruculose, the inner ones light brown, smooth.

NEW COMBINATIONS PROPOSED

Conidiosporomyces verruculosus (Wakfield) K. Vánky, comb. nov.

Basionym: Ustilago verruculosa Wakfield, Bull. Misc. Inform. Kew 1922:162. Type on Setaria aurea A. Br. (= S. sphacelata (Schum.) Moss var. aurea (A. Br.) W. D. Clayton), Congo, I.1914, coll. H. Wanderyst (no. 5054; K!).

Sori as in Conidiosporomyces ayresii (Berk.) K. Vánky. Spores globose, subglobose to ovoid, 17–20 x 17–23 µm (including ornamentation), yellowish-brown, coarsely echinulate, spines (2.5–)3(–4) µm long. Sterile cells subglobose to ovoid, usually collapsed, subhyaline, sparsely to densely, minutely spinulose.

The genus Conidiosporomyces K. Vánky was erected to accomodate Tilletia ayresii Berkeley, type on Panicum maximum Jacq. (Vánky & Bauer, 1992). In C. ayresii the spores measure 12–16 x 13–17 µm, are finely to coarsely, sparsely to densely verrucose. In the scanty type material of C. verruculosus, Y-shaped conidia, typical for C. ayresii, were not observed. The origin of hyphae, cylindrical conidia, and few mycelial or conidial groups, present between the spores of C. verruculosus, is uncertain.

Setaria sphacelata var. aurea, and other Setaria species from the tropics, are usually parasitized by C. ayresii.

Neovossia opaca (H. & P. Sydow) K. Vánky, comb. nov.

Basionym: Tilletia opaca H. & P. Sydow, The Philippine Journal of Science, C. Botany 8:265, 1913. Type on Spinifex squarrosus L. (= S. littoreus (Burman fil.) Merrill; Gramineae), Philippines, Island of Luzon, Prov. Rizal, Paranaque, VII.1911, W. R. Shaw (HCIO!).

Sori in scattered, considerably hypertrophied ovaries, club-shaped, acute cylindrical or acute ovoid, 3–5 x 10–15 mm, green when young, dark brown at maturity, splitting longitudinally to expose the black, powdery mass of spores intermixed with sterile cells. Spores globose or subglobose, rarely broadly ellipsoidal, variable in size and colour, 17–28 x 18–30 µm, medium yellowish-brown to blackish-brown, opaque, often with a papilla or a shorter or longer, thin, hyaline, twisted appendage; wall (2–)2.5–3.5(–4) µm thick, including the evident, hyaline sheath and the prominent, rough warts. Sterile cells subglobose to ovoid, often collapsed, 16–44 µm in diameter, subhyaline to pale yellowish-brown; wall 1.5–5 µm thick, smooth, often with a short, hyaline appendage. Spore germination (on water-agar, after 5 days, at 25 C^{o}) results in nonseptate basidia (one, rarely two per spore) with short, apical branches. Each branch with several tubercles on which up to 64, or more basidiospores are produced per spore. Basidiospores acicular, slightly curved, asymmetrical, hyaline, 1–1.5 x 33–44 µm, germinate without copulation giving rise to hyphae producing ballistospores on short sterigmata.

Durán & Fischer (1961:78) considered *Tilletia opaca* to be a synonym of *T. maclagani* (Berkeley) G. P. Clinton (type on *Panicum virgatum* L., Canada, Montreal, coll. Dr. Maclagan, 545). However, these two species differ markedly in several aspects. The sori of *T. maclagani* are inconspicuous, hidden by the glumes, the spore mass is red-brown, whereas the sori in *Neovossia opaca* are considerably hypertrophied, long protruding from the glumes, the spore mass is black. Spores of *T. maclagani* are yellow to pale yellowish-brown, thick-walled (3.5–4.5 µm), densely, rather finely verrucose, those of *N. opaca* are blackish-brown with (2–)2.5–3.5(–4) µm thick, roughly verrucose wall.

Sporisorium cornutum (H. & P. Sydow & Butler) K. Vánky, comb. nov.
Basionym: *Ustilago cornuta* H. & P. Sydow & Butler, Ann. Mycol. 4:426, 1906. Type on *Ophiurus corymbosus* Gaertn. fil. (= *O. exaltatus* (L.) O. Kuntze; Gramineae, Andropogoneae), India, Gujarat, Surat, 16.VIII.1903, E. J. Butler (no. 447; HCIO!).

Sporisorium cornutum is very close to *S. lepturi* (Thümen) K. Vánky, type on *Hemarthria altissima* (Poiret) Stapf & C. E. Hubbard (Gramineae, Andropogoneae), Egypt, near Damietta, VII.1876, G. Schweinfurth, in Thümen, Mycoth. univ. 1218 (as "*Ustilago carbo* Tul. var. *leptura* Thüm. on *Lepturus incurvatus* Trin."). It differs only by having somewhat smaller spores. These in *S. cornutum* measure 5–7 x 5.5–8 µm, in *S. lepturi* 5.5–8 x 6–9(–10) µm (comp. also Vánky, 1991:162-164).

Sporisorium culmiperdum (Schröter) K. Vánky, comb. nov.
Basionym: *Ustilago culmiperda* Schröter, in Hennings, Hedwigia 35:212, 1896. Syn. *Sphacelotheca culmiperda* (Schröter) G. P. Clinton. Type on *Andropogon bicornis* L., Brazil, St. Catharina, near Joinville, V.1883, E. Ule (1627; BPI).

Sori in the whole inflorescence, long linear, 1–2 mm wide, 3–6 cm long, partly hidden by the terminal leaf sheath, first covered by a dark brown peridium which flakes away revealing a blackish-brown, dusty spore mass surrounding a well-developed columella. Spores globose, subglobose to ovoid, 12–18 x 14–19 µm, dark reddish-brown; wall 1.5–2 µm thick, finely and densely verruculose-echinulate. Sterile cells subglobose to ellipsoidal, pale yellowish-brown. Those of the peridium variable in shape and size, subcubic, subtetrangular or irregular, rarely subglobose, 4–12 x 5–14 µm, arranged in chains, hyaline to pale yellowish-brown, with 0.8–1 µm thick, smooth wall.

Sporisorium holwayi (G. P. Clinton & Zundel) K. Vánky, comb. nov.
Basionym: *Sphacelotheca holwayi* G. P. Clinton & Zundel, in Zundel, Mycologia 22:143, 1930. Type on *Andropogon bicornis* L., Bolivia, Provincia de sur Yungas, Villa Aspiazu, 31.V.1920, W. E. D. and M. M. Holway (686; BPI).

Sori in the spikelets, bunched and forming witches' brooms. One or several witches' brooms of different sizes may occur in the same inflorescence. Individual sori linear, often curved, 0.7–1 mm wide, x 1–4 cm long, first covered by a grayish-brown peridium which splits longitudinally exposing a blackish-brown mass of spores intermixed with few, irregular groups of sterile cells, and a well-developed, central, horn-shaped columella. Spores subglobose, ovoid to irregularly oblong or subpolyhedral, 9–14 x 10–16(–18) µm, dark reddish-brown; wall c. 1.5 µm thick, evidently, moderate densely echinulate. Sterile cells variable in shape and size, smaller than the spores, subhyaline to light yellowish-brown, collapsed with age.

Sporisorium lophopogonis (Thirumalachar & Pavgi) K. Vánky, comb. nov.
Basionym: *Sorosporium lophopogonis* Thirumalachar & Pavgi, Sydowia 20:23, 1967(1968). Type on *Lophopogon tridentatus* Hack., India, Poona, X.1954, M. J. Thirumalachar.

Sori usually in the whole panicle, partly hidden by the uppermost leaf sheath, long linear, 10–40 mm x 1–1.5 mm, rarely only in the spikelets, first covered by a pale yellowish peridium of fungal origin which flakes away exposing the black, granular-powdery mass of spore balls, relatively few groups of sterile cells and a long, fine, slender, central columella of host origin. Spore balls semipermanent, subglobose, ellipsoidal or irregular, 40—100 x 45—130 µm, dark reddish-brown, opaque, composed of many of spores. Outer spores subglobose, ovoid or slightly irregular, 9—12 x 11—13.5 µm, dark brown, thick-walled (1—2.5 µm), densely and coarsely echinulate on the free surface, spines 1—2 µm high. Inner spores subpolyhedrally irregular, pale yellowish-brown, thin-walled (c. 0.5 µm), smooth. Peridial cells in chains, subcuboid, subtetrangular, subglobose or ovoid, 5.5—9.5 x 4—13 µm, subhyaline, smooth.

Sporisorium sacciolepidis (Thirumalachar) K. Vánky, comb. nov.

Basionym: Sphacelotheca sacciolepidis Thirumalachar (as "saccolepidis"), Lloydia 13:173, 1950. Type on Sacciolepis indica (L.) Chase, India, Mysore, Bhadravati, 18.VIII.1947, leg. H. C. Govindu (HCIO 18808!).

Sori in all ovaries of a panicle, inconspicuous, hidden by the floral envelopes, first covered by a brownish peridium of fungal origin which flakes away at maturity exposing the black spore mass mixed with groups of sterile cells and a short, central columella. Mature spores single, globose, subglobose to ovoid, 9.5—12 x 10.5—13 µm, reddish-brown, densely and evidently echinulate. Sterile cells subglobose to irregular, 8—12 µm long, subhyaline, thin-walled, smooth.

Urocystis narcissi (González Fragoso) K. Vánky, comb. nov.

Basionym: Urocystis colchici (Schlecht.) Rabenh. f. narcissi González Fragoso, Trabajos del Museos Nacional de Ciencias Naturales, Seria Botánica 7:22, 1914. Syn. Tuburcinia narcissi (Gz. Frag.) Ciferri, 1938:101. Type on Narcissus sp. (Amaryllidaceae), Spain, Mts. Guadarrama, Estación Alpina de Biologia, 25.VI.1914, R. González Fragoso (MA 549!, BPI 178611!).

Sori in the leaves and scales as dark pustules containing a black, powdery mass of spore balls. Spore balls subglobose, ellipsoidal to irregular, 25—40 x 25—50 µm, composed of 1—3(—4) spores completely surrounded by sterile cells. Spores globose, subglobose, ovoid to elongated, 12—16 x 13—20 µm, dark reddish-brown, smooth. Sterile cells variable in shape, size and wall-thickness, subglobose, elongate or irregular, 6—20 µm long, wall 1—3(—5) µm thick, yellowish-brown, smooth.

According to Prof. Caballero (in González Fragoso, 1914:23) the host plant could be Narcissus pallidulus (= N. triandrus L. subsp. pallidulus (Graells) D. A. Webb), or N. graellsii Graells (= N. bulbocodium L. subsp. bulbocodium).

SYNONYMS

Bauhinus Moore = nomen novum superfluum pro Microbotryum Léveillé.

During the last ten years much data has been published indicating that the smut fungi on dicots are in several aspects markedly different from those on monocots. For a small group of studied dicot smuts Deml & Oberwinkler (1982) reintroduced the old name Microbotryum Léveillé (type: M. antherarum Lév.) and applied it for several anther smuts of Caryophyllaceae. Prillinger & al. (1991) emended Léveillé's name and included in Microbotryum a further two species from Polygonaceae (M. cordae (Liro) G. Deml & Prillinger, and M. vinosum (L.-R. & C. Tul.) G. Deml & Prillinger) and two species from Compositae (M. scabiosae (Sow.) G. Deml & Prillinger, and M. scorzonerae (Alb. & Schw.) G. Deml & Prillinger). Moore (1992), based on the papers of Blanz & Gottschalk (1984) and Deml (1987), proposed the new name Bauhinus (type: Uredo tragopogonis-pratensis Persoon) for all dicot smuts. Because Microbotryum species, including the type, are dicot smuts, the name Bauhinus is superfluous (Article 63 of the ICBN).

Ustilago holubii and *Sphacelotheca almorae* = *U. trichophora*.

Fullerton (1966) and Fullerton & Langdon (1969) proved that there are no essential differences in the spore size and ornamentation between *Ustilago trichophora*, *U. sphaerogena*, *U. crus-galli*, *U. panici-frumentacei* (all on *Echinochloa* spp.), and *U. globigena* (on *Panicum spectabile* Nees ex Trin.). The sorus structure is also similar in these smuts, irrespective of its localization in the floral organs or in the vegetative parts of the host plants. Consequently, Fullerton concluded that all these names represent the same species.

A study of the isotype of *Ustilago holubii* H. Sydow (1935:230), on *Echinochloa holubii* (Stapf) Stapf (= *E. pyramidalis* (Lam.) Hitchc. & Chaise), Union of South Africa, Transvaal, Pretoria, Prinshoff, 30.I.1930, C. Liebenberg (24942; HUV 3738) showed that this species also is identical with *U. trichophora* (Link) Körnicke (type on *Echinochloa colonum* (L.) Link, Egypt, C. G. Ehrenberg). For this smut the hispid sorus membrane is typical. The spores are globose, subglobose to ovoid, 6–11 x 7–12 µm in diameter, sparsely to moderately densely punctate-tuberculate or echinulate, light olivaceous-brown; in SEM sparsely to moderately densely, minutely verruculose between the coarse, low to high spines.

The study of the topotype of *Sphacelotheca almorae* A. Krishna & R. A. Singh (1979:177), type on *Echinochloa frumentacea* Link, India, Uttar Pradesh, Almora, 25.IX.1977, R. A. Singh (IMI; topotype in Vánky, Ust. 897), showed that it is also identical with *U. trichophora* (Link) Körnicke.

EXCLUDED SPECIES

Sorokin (1873:28) described *Ustilago mirabilis* on *Phragmites communis* collected in Germany. Later, the name of this curious fungus was forgotten and not mentioned in the literature. The sori appear on the stems as black, powdery, fusiform pustules. The spores, according to Sorokin, are "globose, 0.0097–0.0156 mm, smooth, with a lucid kernel. During germination the exospore splits into two hemispheres and a ramified, multicellular, chain-like mycelium arises on which sporidioles are produced".

No material of *U. mirabilis* has been seen, and it is not known where the type is deposited. From the description and the analysis of Sorokin's illustrations (Pl. V, figs. 28–35) I suspected that this fungus is not a smut.

I recently collected stems of *Phragmites australis* (Cav.) Trin. ex Steudel (*Ph. communis* Trin.) with a hyphomycete possessing sori and spores very similar to those of the description and illustrations of *U. mirabilis*. The fungus was identified by Dr. G. Weber as *Arthrinium phaeospermum* (Corda) M. B. Ellis (Hyphomycetes), which is the most probable name for Sorokin's fungus.

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PORE FUNGI OF COSTA RICA III

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This is the third and last part of a comprehensive list of the polypores of Costa Rica. The first two parts were published elsewhere (Carranza-Morse, 1991; 1992).

A total of 69 genera and 193 species are reported in these papers, which represents 58% of pore fungi reported from other tropical countries (Ryvarden and Johansen, 1980). The large number of species present on such a small area (total area 51.100 Km^2) is probably due to its geographical position with very changing climates and a migration of species from both the North and South American mycoflora.

Most of the species listed in these papers (Carranza-Morse op. cit.) have been reported by other mycologists (Covington, 1980; Furtado, 1981; Gómez & Ryvarden, 1985; Larsen and Cobb Poulle, 1990; Lowe, 1963; 1966; 1976; Murrill, 1915; Sydow, 1925;), but they are included to give a better idea of the fungal diversity in the country. The specimens are deposited in the Herbarium of the School of Biology, University of Costa Rica (USJ), in the Herbarium of the USDA at Beltsville, Maryland (BPI), or in the Herbarium of the National Museum, Costa Rica (CR).

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MATERIALS AND METHODS

Free hand sections were prepared from each specimen and mounted in 3% KOH to which a drop of aqueous phloxine was added, and in Melzer's reagent. Observations were done under a light microscope.

The families are listed in alphabetical order as are genera within each family. Herbarium abbreviations are from Holmgren et al. (1981). Species preceded by an asterisk (*) are new records for the country.

LIST OF FUNGI

Corticeaceae

***Grammothele setulosa** (Henn.) Ryv., A Prelim. Polyp. Fl. East Africa, p.45. 1980.
Poria setulosa Henn., Engl. Bot. Jahrb. 28:321. 1901.
Trametes subserpens Murr., Mycologia 12:108. 1920.

Voucher specimen examined: Carpintera, Cartago, K.A. Danielson 28 (BPI 249432). No duplicates at USJ. (Altitudinal distribution: 1524 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

***Trechispora mollusca** (Pers.:Fr.) Lib., Can. J. Bot. 51:1878. 1973.
Poria candidissima (Schw.) Cke., Grevillea 14:111. 1886.
Polyporus molluscus Pers.:Fr., Syst. Mycol. 1:384. 1821.

Voucher specimen examined: Birri, Heredia, J. L. Lowe 12886 (USJ 9801). (Altitudinal distribution: 1432 m).

Type of rot: White rot.
Substrata: On hardwood and softwood trees, on dead leaves and polypores.
Distribution: North and Central America; Europe; New Zealand; Australia; Africa.

Trechispora regularis (Murr.) Lib., Can. J. Bot. 51:1878. 1973.
Poria regularis Murr., Mycologia 12:87. 1920.

Voucher specimens examined: Tacares, Heredia, J.L.Lowe 13458 (USJ 9771); Birri, Heredia, J.L. Lowe 13086 (USJ 9772). Jardín de Dota, San José, J.L. Lowe 13040 (USJ 21992). (Altitudinal distribution: 670-1981 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Ganodermataceae

Ganoderma amazonense Weir, Bull. USDA 1380:93, pl. 6. 1926.

Comments: Basidiospores 6.4-8.0 x 5.2-6.4 um, smaller than reported by Furtado (1967).
Voucher specimen examined: Caño Negro Reserve, Alajuela, A. Ruiz-Boyer 7-91 (USJ 36351). (Altitudinal distribution: sea level).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America; Caribbean Islands.

Hymenochaetaceae

***Phellinus melanodermus** (Pat.) O. Fidalgo, Mem. New York Bot. Gard. 17:135. 1968.
Fomes melanodermus Sacc., Syll. Fung. 14:182. 1899.
Xanthochrus melanodermus Pat., Ann. Jard. Bot. Buitenzorg. Suppl. 1:113. 1897.

Voucher specimen examined: Yerba Buena, N.E. of San Isidro, Heredia, P.C. Standley 49694, J. Valerio, 1926 (BPI 231893). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America; Asia.

Polyporaceae

***Ceriporiopsis umbrinescens** (Murr.) Ryv., Mycotaxon 23:169-198. 1985.
Poria umbrinescens Murr., Mycologia 12:83. 1920.

Voucher specimen examined: Costa Rica, C.W. Dodge 7376, 1934
(BPI 243947). No duplicates at USJ.
Type of rot: White rot.
Substrata: On monocots (palm).
Distribution: Central America; Caribbean Islands.

Coriolopsis substuppeus (Berk. & Cke.) Ryv., Mycotaxon 20:329-363. 1984.
Polyporus substuppeus (Berk. & Cke.), Linn. Soc. J. Bot. 15:380. 1876.

Voucher specimen examined: Road to Volcán Poás, Alajuela, A. L. Welden 3175 (TU 9052, USJ 22039). (Altitudinal distribution: 1148 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America

***Fomitopsis scutellata** (Schw.) Bond. & Sing., Ann. Mycol. 39:55. 1941.
Fomes scutellatus (Schw.) Cke., Grevillea 14:19. 1885.
Polyporus scutellatus Schw., Trans. Amer. Phil. Soc. II, 4:157. 1832.

Voucher specimen examined: Finca Castilla, forest near farm house, Limón, C.W. Dodge 9257, V.F. Goerger, 1936 (BPI 234659). No duplicates at USJ.
Type of rot: Brown rot.

Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Australia; Africa; Caribbean Islands; New Zealand.

***Physisporinus vitreus** (Pers.:Fr.) Karst., Finl. Basid. sv. p.324. 1889.
Polyporus vitreus Pers. : Fr., Syst, Mycol. 1:381. 1821.

Voucher specimen examined: Paqueta Hill, Costa Rica, C.W. Dodge 9840 (BPI 243962). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood rarely on softwood trees.
Distribution: North and Central America; Europe; New Zealand.

Rigidoporus lineatus (Pers.) Ryv., Norw. J. Bot. 19:236. 1972.
Polyporus lineatus Pers., in Gaudichaud, Vouyage aut. du Monde, p. 174. 1827.

Voucher specimens examined: Alajuela, San Carlos, Tres Amigos , R.C. Lorenz 3094 (BPI 226448); Costa Rica, Chitaria, M. Valerio (BPI 226246); Alajuela, vicinity of Los Chiles, Rio Frio, W. Holm, H.H. Iltis 1571 (BPI 226445). No duplicates at USJ. (Altitudinal distribution: 700 m).
Type of rot: White pocket rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Africa.

Rigidoporus microporus (Fr.) Overeem., Icon. Fung. Malayensum 5:1. 1924.
Polyporus microporus Fr., Syst. Mycol. 1:376. 1821.

Comments: A more detailed description is given by Carranza & Sáenz (1984).

Rigidoporus ulmarius (Sow.: Fr.) Imazeki, Bull. Govt. Forest Exp. Stn. Meguro 57:119. 1952.
Polyporus ulmarius Sow. :Fr., Syst. Mycol. 1:365. 1821.

Voucher specimen examined: Echandi Lake, Costa Rica,

D.E. Stone (TU 528, USJ 21292).
Type of rot: Yellowish, stringy root and butt rot of living trees.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe; Africa Cosmopolitan species.

Rigidoporus vinctus (Berk.) Ryv., Norw. J. Bot. 19:139. 1972.
Poria vincta Berk., Ann. Mag. Nat. Hist. 2,9:196. 1852.

Voucher specimens examined: Río Claro, San José, J.L. Lowe 12831 (USJ 9787); Tacares, Heredia, J.L. Lowe 13461 (USJ 9786); Ciudad Colón, San José, J.L. Lowe 13218 (USJ 9785). (Altitudinal distribution: 670-822 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Africa.

Schizopora paradoxa (Fr.)Donk., Persoonia 5:76. 1967.
Poria versipora (Pers.) Rom., Svensk Bot. Tidskr. 20:15. 1926.
Hydnum paradoxum Fr., Syst. Mycol. 1:424. 1821; Elench Fung. 1:150. 1828.

Voucher specimens examined: El Empalme, San José, J.L. Lowe 13204 (USJ 9761); Vara Blanca, Alajuela, J.L. Lowe 13016 (USJ 22018); Uvita, Heredia, J.L. Lowe 13116 (USJ 9764); Cartago, Cartago, J. L. Lowe 12878 (USJ 9676). (Altitudinal distribution: 1828-2499 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe; Africa. Cosmopolitan species.

***Skeletocutis roseolus** (Rick ex Theiszen) Raj., Nord. J. Bot. 7:553-568. 1987.
Polystictus roseolus Rick ex Theiszen, Denksch. Math. Naturw. Kl. Akad. Wien. 83:239. 1911.

Voucher specimens examined: Costa Rica, El Muñeco, on the Rio Navarro, Provincia de Cartago, P.C. Standley

51318, R. Torres (BPI 218948). No duplicates at USJ. (Altitudinal distribution: 1400-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America.

***Spongipellis pachyodon** (Pers.) Kotl. & Pouz., Ceská Mykol. 19:77. 1965.
Hydnum pachyodon Pers., Mycol. Europ. 2:174. 1825.

Comments: Only one specimen deposited at CR. No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe.

***Tinctoporellus epimiltinus** (Berk. & Br.) Ryv., Trans. Br. Mycol. Soc. 73:18. 1979.
Polyporus epimiltinus Berk. & Br., J. Linn. Soc. 14:54. 1873.

Voucher specimens examined: Parque La Amistad, San Vito, Coto Brus, Puntarenas, J.C. Morse 203-87 (USJ 27578); Grecia, Alajuela, J.C. Morse 94-86 (USJ 22963); La Virgen, Heredia, J.L. Lowe 13290 (USJ 9803). (Altitudinal distribution: 213-1009 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands; Africa.

***Trametes cervina** (Schw.) Bres., Ann. Mycol. 1:81. 1903.
Boletus cervinus Schw., Syn. Fung. Carol., p.70. 1822.

Comments: Basidiospores 6.0-7.0 x 2.0-2.5 um, smaller than reported by Gilbertson & Ryvarden (1987).
Voucher specimens examined: Santa Ma. de Dota, San José, Standley (USJ 21093); Monte de la Cruz, Heredia, L.D. Gómez 24197 (USJ 22894). (Altitudinal distribution: 1800-2021 m).
Type of rot: White rot.
Substrata: On hardwood rarely on softwood trees.
Distribution: North and Central America; Europe; Africa.

***Trametes cubensis** (Mont.) Sacc., Syll. Fung. 9:198. 1891.
Polyporus cubensis Mont., Ann. Sci. Nat. Bot. II, 8:364. 1837.

Voucher specimens examined: Bosque Esquinas, Golfito, Puntarenas. R. González Ch. (JCM 2-91, USJ 33127); Cerro Chocuaco, Sierpe de Osa, Puntarenas, R. González Ch. (JCM 15-91, USJ 33280). (Altitudinal distribution: 100-350 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Trametes drummondii (Kl.) Ryv., Mem. New York Bot. Gard. 28(1):202. 1976.
Polyporus drummondii Kl., Linnaea 8:487. 1833.

Voucher specimen examined: Along gravel road behind town leading to radio tower, Golfito, Puntarenas (TU 9433, USJ 21084).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America.

Trametes fibrosa Fr., Epicrisis Myc. p.490. 1838.

Comments: Listed by Covington (1980). No duplicates at USJ.

Trametes hirsuta (Wulf.:Fr.) Pil., Atl. Champ. Europ. 3:265. 1939.
Polyporus hirsutus Wulf.:Fr., Syst. Mycol. 1:367. 1821.

Voucher specimens examined: San José de la Montaña, Heredia, L.D. Gómez 24256 (USJ 22901); Pan American Highway near El Empalme, D.E. Stone (TU 518, USJ 21089). (Altitudinal distribution: 1700-2221 m).
Type of rot: White rot.
Substrata: On hardwood rarely on softwood trees.
Distribution: North and Central America; Europe.

***Trametes maxima** (Mont.) David & Rachj., Mycotaxon 22:315. 1985.

Irpex maximus Mont., Ann. Sci. Nat. Bot. ser. 2, Vol. 8:364. 1837.

Comments: Basidiospores 5.0 x 3.0 um.
Voucher specimens examined: Palo Verde, Guanacaste, L.D. Gómez 24271 (USJ 22869); San Antonio de Coronado, San José, L.D. Gómez 24209 (USJ 22879); Cañas, Guanacaste, JCM 91-79 (USJ 21269). (Altitudinal distribution: 100-1380 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands.

Trametes membranacea (Sw.: Fr.) Kreisel, Ciencias Biol. ser. 4, no. 16:83. 1971.
Polyporus membranaceus Fr., Syst. Mycol. 1:370. 1821.

Comments: Basidiospores 4.0-4.8 x 2.4 um, hyaline, smooth walled, cylindric to oblong; smaller than reported by Gilbertson and Ryvarden (1987).
Voucher specimens examined: La Gloria de los Planes, Sierpe de Osa, Puntarenas, R. González (JCM 10-91, USJ 33153); Navarro, Costa Rica, A.L. Welden 3016 (USJ 22068). (Altitudinal distribution: 200 m).
Type of rot: White rot.
Substrata: On hardwood rarely on softwood trees.
Distribution: North, Central and South America.

Trametes menziezii (Berk.) Ryv., Norw. J. Bot. 19:236. 1972.
Polyporus menziezii Berk., Ann. Nat. Hist. 10-378. 1843.
Polyporus subzonalis Cke., Grevillea 19:44. 1890.

Comments: A more detailed description is given by Carranza & Saénz (1984).

Trametes pavonia (Hook.) Ryv., Norw. J. Bot. 19:237. 1972.
Polyporus pavonius (Hook.) Fr., Epicr. Syst. Mycol. p. 477. 1838.
Boletus pavonius Hook., in Kunth., Syn. Pl. 1:10. 1822.

Comments: A more detailed description is given by

Carranza & Saénz (1984).

Trametes pubescens (Schum.: Fr.) Pil., Atl. Champ. Europ. 3:268. 1939.
Polyporus pubescens Schum.: Fr., Syst. Mycol. 1:367. 1821.

Comments: Basidiospores 4.0 -5.0 x 2.0 um, smaller than reported by Gilbertson & Ryvarden (1987).
Voucher specimen examined: Jardín José Ma. Orozco, Ciudad Universitaria, San Pedro, San José, JCM 50-79 (USJ 21124). (Altitudinal distribution: 1205 m).
Type of rot: White rot.
Substrata: On hardwood **(Psidium guajaba)** , rarely on softwood trees .
Distribution: North and Central America; Africa; Europe. Cosmopolitan species.

Trametes roseola Pat. & Har., Bot. 14:239. 1900.

Comments: Listed by Covington. No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa; Asia.

Trametes versicolor (L.: Fr.) Pil., Atl. Champ. Eur. 3:261. 1936.
Polyporus versicolor Fr., Syst. Mycol. 1:368. 1821.

Comments: A more detailed description is given by Carranza & Sáenz (1984).

Trametes villosa (Fr.) Kreisel, Ciencias Biol. Ser. 4, no. 16:84. 1971.
Polyporus pinsitus Fr., Elench. Fung. 1:95. 1828.
Polyporus villosus Fr., Syst. Mycol. 1:344. 1821.

Comments: Basidiospores 4.0-8.0 x 3.0-4.0 um, cylindric to allantoid, hyaline, similar to the ones described by Gilbertson and Ryvarden (1987).
Voucher specimens examined: Santa Ma. de Dota, San José, JCM 37-88 (USJ 27932); Las Cruces, San Vito de Coto Brus Puntarenas, JCM 209-86 (USJ 22774);

Universidad de Costa Rica, San Pedro, San José, JCM 13-85 (USJ 22338); Limón, Limón, JCM 125-80 (USJ 21897). (Altitudinal distribution: 3-2221 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North, Central and South America; Africa; Caribbean Islands.

Trichaptum biforme (Fr. in Kl.) Ryv., Norw. J. Bot. 19:237. 1972.
Polyporus biformis Fr., Kl. Linnaea 8:486. 1833.

Comments: A more detailed description is given by Carranza & Saenz (1984).

Trichaptum byssogenum (Jungh.) Ryv., Norw. J. Bot. 19:237. 1972.
Polyporus byssogenus Jungh. Verh. Batav. Genootsch. 17:43. 1838.

Comments: A more detailed description is given by Carranza & Saenz (1984).

Trichaptum fumoso-avellanea (Rom.) Rajchenb. & Bianch., Nord. J. Bot. 11(2):225-230. 1991.
Trametes fumoso-avellanea Rom., Bih. K. sv. Vet. Akad. Hand. Vol. 26, ser. 3, no. 16 p. 13. 1901.

Comments: Listed by Covington (1980). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America.

Trichaptum perrottetii (Lév.) Ryv., Norw. J. Bot. 19:229-239. 1972.
Polyporus perrottetii Lév., Ann. Sci. Nat. Ser. 3, Vol. 2:195. 1844.
Polyporus trichomallus Berk. & Mont., Ann. Sci. Nat. Bot. III, Vol. 11:238. 1849.

Comments: A more detailed description is given by Carranza & Saenz (1984).

Trichaptum sector (Ehrenb.:Fr.) Kreisel, Ciencias Ser. 4. Cienc. Biol. no. 16:84. 1971.
Polyporus sector Ehrenb.:Fr., Syst. Mycol. 1:505. 1821.
Boletus sector Ehrenb., Horae Phys. Berol., p. 86. 1820

Comments: A more detailed description is given by Carranza & Saenz (1984).

Tyromyces caesioflavus (Pat.) Ryv., Papers Farlow Herb. 18, p.9. 1983.
Polyporus caesio-flavus Pat., Bull. Soc. Myc. France 8:113-140. 1892.

Comments: A more detailed description is given by Carranza (1982)

Tyromyces cerifluus (Berk. & Curt.) Murr., North Am. Flora 9:33. 1907.
Polyporus cerifluus Berk. & Curt., Grevillea 1:50. 1872.

Comments: A more detailed description is given by Carranza & Saenz (1984).

***Tyromyces floriformis** (Quél.) Bond. & Sing., Ann. Mycol. 39:51. 1941.
Polyporus floriformis Quél. in Bres. Fungi Trid. 1:61. 1884.

Voucher specimen examined: Palo Verde, Guanacaste, L.D. Gomez 24266 (USJ 22827). (Altitudinal distribution: 100 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North and Central America; Europe.

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MYCOTAXON

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PIROMYCES SPIRALIS, A NEW SPECIES OF ANAEROBIC FUNGUS FROM THE RUMEN OF GOAT

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ABSTRACT

Piromyces spiralis, a new species of anaerobic fungus from the rumen of goat is described and illustrated. The fungus is monocentric with endogenous sporangia and coiled main and secondary rhizoids. Sporangia are highly evanescent.

The genus *Piromyces* was established by Gold *et al.*, (1988) with *Piromyces communis* as the type species. The genus is characterised by anaerobic fungi with monocentric thallus development, much-branched, filamentous rhizoids, globose, ovoid, ellipsoidal or irregular sporangia and uniflagellated or occassionally biflagellated to quadriflagellated zoospores. So far, five species have been formally described and included in this genus. They are *P. communis* Gold

(Gold *et al.*, 1988, = *Piromonas communis* Sensu Orpin, 1977), *P. mae* Li (Li *et al.*, 1990), *P. dumbonica* Li (Li *et al.*, 1990), *P. rhizinflata* Breton (Breton *et al.*, 1991) and *P. minutus* Ho (Ho *et al.*, 1993a).

Recent isolation of fungi from the rumen of katjang goat (*Capra hircus*) fed guinea grass (*Panicum maximum) ad libitum* yielded an isolate (G34) belonging to the genus *Piromyces* but appears to be distinct from the five *Piromyces* species described.

The fungus was isolated from the rumen contents of a goat using the method described by Ho & Bauchop (1991). The media for culturing the isolates were glucose sloppy agar, cellulose sloppy agar and liquid medium with Whatman No. 1 filter paper or rice straw as carbon source (Ho & Bauchop, 1991).

Piromyces spiralis Ho sp. nov. Figs. 1-14.

Thallus monocentricus eucarpus. Sporangia globosa vel subglobosa, 14-100 x 15-120 µm, endogena, evanescentia. Axis rhizoidei singularis, aliquando 2-3 (duo vel tres), collo tubulari vel constricto, torta ampla ramosa. Zoosporae globosae vel subglo-bosae, 4-7 x 4-8.5 µm, uniflagellate interdum biflagellatae vel quadriflagellatae, flagellis 26-34 µm longis, dissolutione rapida parietis sporangii dimissae. Ex rumine caprae, in Malaysia. Species obligate anaerobia.

Thallus monocentric, eucarpic. Sporangia globose to subglobose, 14-100 x 15-120 µm, endogenous, evanescent. Rhizoidal axis single, occasionally two to three, neck tubular to constricted. Rhizoids twisted, extensive and branched. Zoospore discharge by rapid dissolution of sporangial wall. Zoospores globose to subglobose, 4-7 x 4-8.5 µm, uniflagellate, occasionally biflagellate to quadriflagellate, flagellum 26-34 µm long. From the rumen of goat, Malaysia. Obligate anaerobe.

In the rumen contents of katjang goat (*Capra hircus*), Universiti Pertanian Malaysia (UPM), Serdang, Malaysia, 20 May, 1992, Y.W. Ho and D.J.S. Barr. Type: Figs. 1-14. A culture, G34, is being maintained at UPM.

The zoospores of *P. spiralis* are globose (Fig. 1) to subglobose, 4-7 x 4-8.5 µm, or irregular to amoeboid before encystment. They are usually monoflagellated, occasionally biflagellated to quadriflagellated. The flagellum is posteriorly orientated, 26-34 µm long including a short whiplash. Shed flagella usually possess a bead-like structure (0.7-1.5

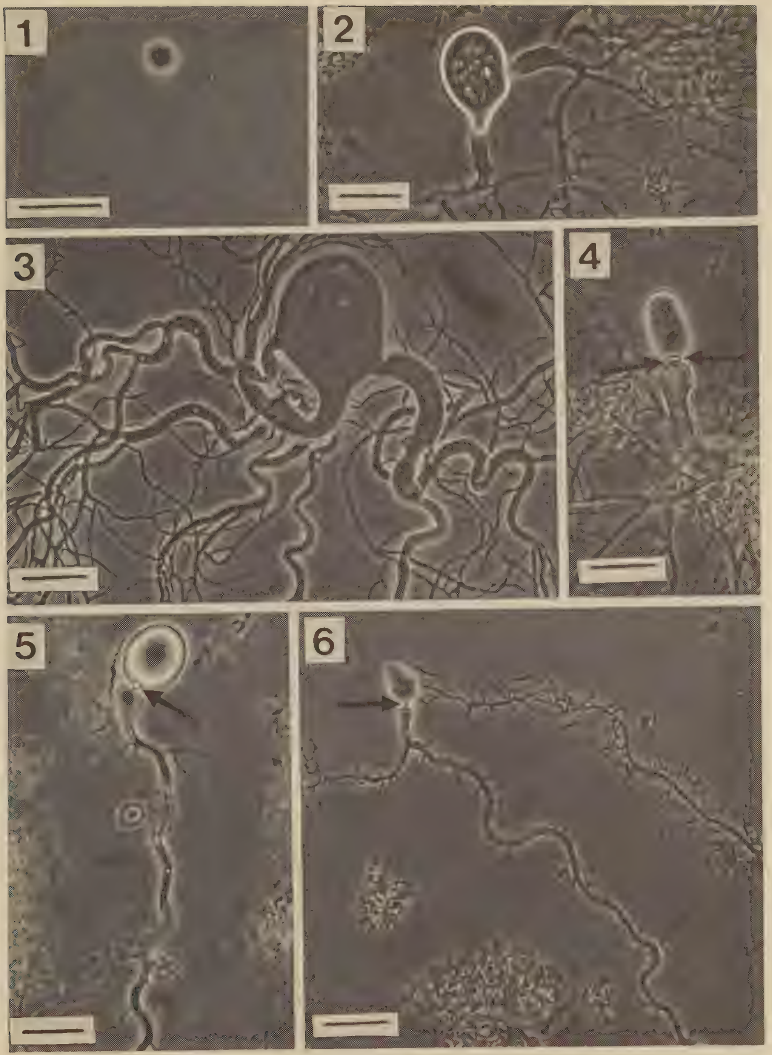


Fig. 1. Zoospore of *P. spiralis*. Fig. 2. Thallus with two rhizoidal axes. Fig. 3. Thallus with three rhizoidal axes. Fig. 4. Main rhizoid with a subsporangial swelling, short constricted neck and very narrow port. The sides of the constricted neck are refringent appearing as two bright spots (arrows). Fig. 5. Main rhizoid with a subsporangial swelling, short constricted neck and a moderately wide port (arrow). Fig. 6. Main rhizoid with subsporangial swelling and a constricted, elongated isthmus-like neck (arrow). Bar = 20 μm.

μm in diameter) at one end. Similar flagellar structure in zoospores of *Neocallimastix* spp. and *P. minutus* has been reported by Barr *et al.*, (1989) and Ho *et al.*, (1993a & b).

Germination of zoospores produces endogenous type of thallus development in all the media used. The encysted zoospore expands and produces a germ tube which very quickly elongates and enlarges to form the main rhizoid. Usually, there is one rhizoidal axis, but occasionally, there are two or three (Figs. 2&3).

Generally, the main rhizoid can be differentiated into three types. In the first type, the neck (the part between the sporangium and main rhizoid) and port (the opening in the neck) are constricted. The sides of the constricted neck are sometimes very refringent, appearing as two bright spots beside the neck (Fig. 4). The neck can be short (Figs. 4 & 5) or elongated and isthmus-like (Fig. 6). The main rhizoid below the neck is bulbous and swollen (subsporangial swelling). The subsporangial swelling can be irregularly bulbous or somewhat spherical (Figs. 7 & 8) with a diameter ranging from 4-19.5 μm. Similar subsporangial swelling and constricted neck have been observed in *P. rhizinflata* by Breton *et al.* (1991). Li *et al.* (1990) have also reported the presence of subsporangial swelling in *P. mae* but no mention was made of the constricted neck. Subsporangial swelling and constricted neck are common characteristics of the aerobic chytrids *Spizellomyces acuminatus* Barr, *S. punctatus* (Koch) Barr and *S. kniepii* Gaertner ex Barr (Barr, 1984). With respect to these two characteristics, *P. spiralis* and *P. rhizinflata* resemble the *Spizellomyces* spp. more than any of the other chytrids.

In the second type of main rhizoid, the neck and port are also constricted and the sides of the neck are sometimes refringent but there is no subsporangial swelling. The main rhizoid below the neck is tubular and barely inflated (Figs. 9A & B). In the third type, the neck and port are not constricted but wide and the main rhizoid tapers rather evenly (Figs. 10A & B).

The main rhizoid in all the three types is often coiled, forming loose spirals or close loops below the subsporangial swelling or a short distance from the neck if the subsporangial swelling is absent (Figs. 3-10). Spirals and coils in the main rhizoid are formed during the early developmental stage of the thallus (Figs. 5-10A). As coiled secondary branches are produced from the main rhizoid in later developmental stages, an extensive rhizoidal system made up of coiled rhizoids (up to 700 μm long) is formed (Fig. 11). Although coiled rhizoids are formed in all the culture media, they are most distinctive in glucose sloppy agar.

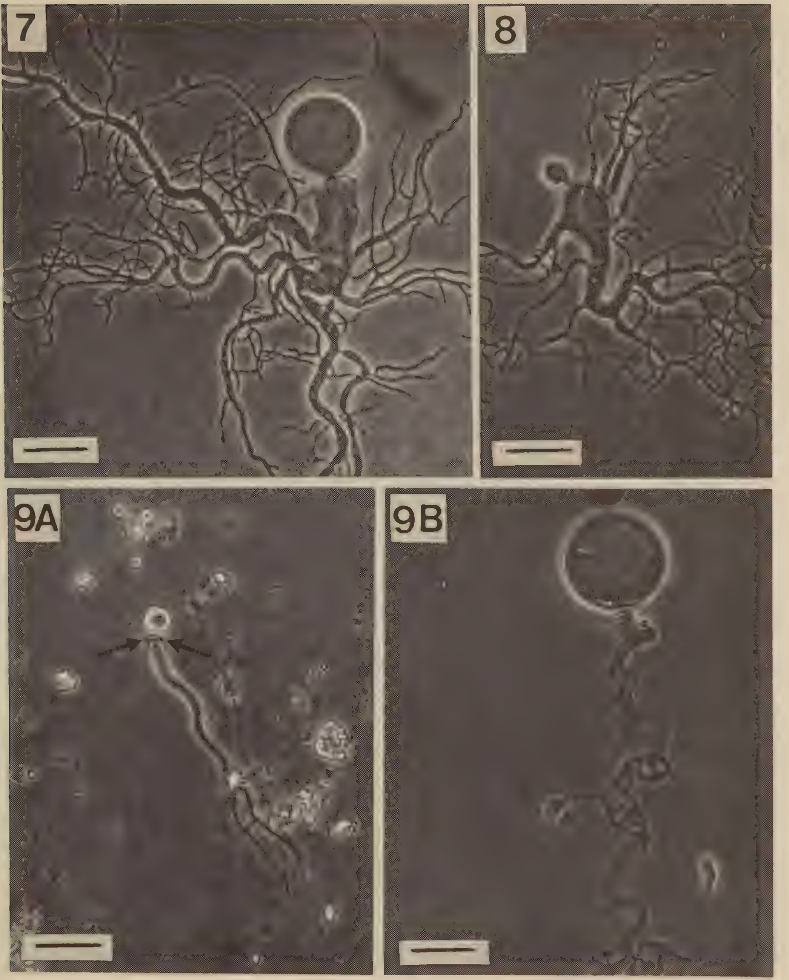
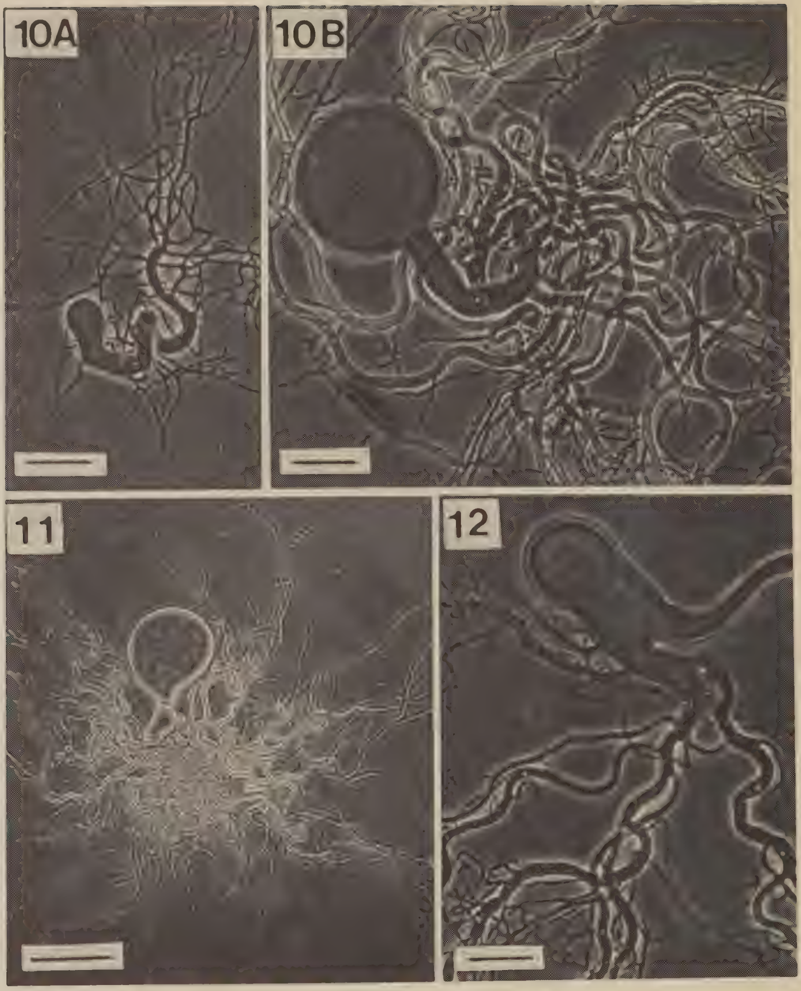


Fig. 7. Main rhizoid with an irregularly bulbous subsporangial swelling. Fig. 8. Main rhizoid with a somewhat spherical subsporangial swelling. Figs. 9A-B. Main rhizoid with a constricted neck and very narrow port but no subsporangial swelling. The main rhizoid below the neck is tubular and barely inflated. Note the refringent sides of the constricted neck in Fig. 9A. (arrows). Bar = 20 μm.



Figs. 10A-B. Main rhizoid with wide neck and port. The main rhizoid tapers rather evenly. Bar = 20 µm. Fig. 11. A thallus with an extensive rhizoidal system made up of coiled rhizoids. Bar = 100 µm. Fig. 12. An irregularly shaped sporangium. Bar = 20 µm.

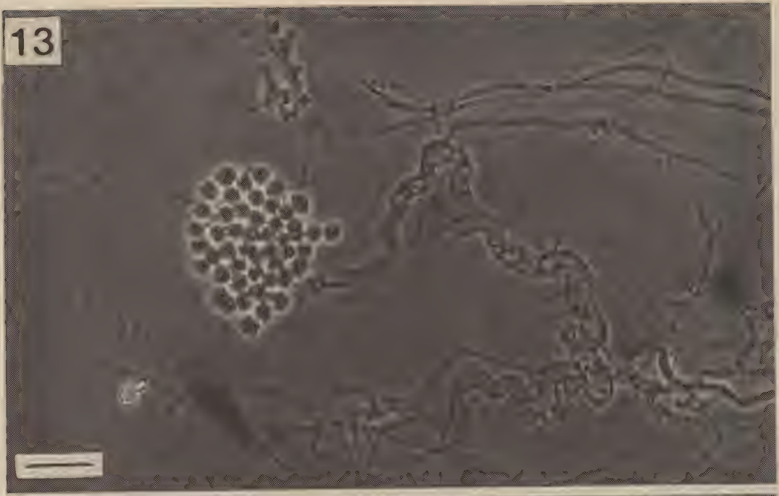
In thalli with more than one rhizoidal axes, the main rhizoids can be a mixture of the three types of rhizoids described above or they can all be of one type (Figs. 2 & 3).

Rhizoids of *P. spiralis* are quite even over their length and rarely have swellings and constricted points which when present make them appear bead-like such as those found in *P. communis* (Barr, *et al.*, 1989), *P. minutus* (Ho *et al.*, 1993a) and *Neocallimastix* spp (Barr *et al.*, 1989; Ho *et al.*, 1993b). The ends of the rhizoids are more or less straight with moderately blunt tips.

The sporangium develops by enlargement of the encysted zoospore. Sporangia are globose, broadly ellipsoidal to pyriform (Figs. 2-10) but occasionally irregular (Fig. 12). Sporangium size is very variable, ranging from 14-100 μm in diameter and 15-120 μm long.

Zoospore release is through rapid dissolution of the whole sporangial wall. The highly evanescent sporangial wall is very distinctive in *P. spiralis.* Dissolution of the sporangial wall is so rapid that it is usually completed before the zoospores have a chance to swim away. Thus, the zoospores are often found in a cluster or glomerule on the main rhizoid without a sporangial wall (Fig. 13). Empty sporangia after zoospore release have not been observed in *P. spiralis.* This is in contrast to *Neocallimastix* spp, *P. communis* and *P. minutus* where the sporangial wall is more persistent and empty sporangia following zoospore release are frequently found (Barr *et al.*, 1989; Ho *et al.*, 1993 a & b). Usually, only tiny bits of basal sporangial wall are seen attached to the main rhizoid (Fig. 14) in *P. spiralis.* Breton *et al.* (1991) have observed that zoospores of *P. rhizinflata* sometimes remained clustered in glomerules on the main rhizoid but we are uncertain whether this is the result of the rapid dissolution of the sporangial wall since they have reported that the zoospores are usually released through an apical pore in the sporangial wall.

The highly evanescent sporangia and coiled main and secondary rhizoids are the distinctive features which separate *P. spiralis* from the other *Piromyces* species. Although in *P. communis*, the zoospores are released following overall dissolution of the sporangial wall (Barr *et al.*, 1989), the dissolution is not as rapid as that in *P. spiralis* and empty sporangia after zoospore release are often observed. Zoospore release in *P. mae* is through papillae (Li *et al.*, 1990) and in *P. rhizinflata* and *P. minutus* through apical pore(s) (Breton *et al.*, 1991; Ho *et al.*, 1993a). Although coiling of rhizoid occurs in *P. minutus*, it is only confined to the main rhizoid.



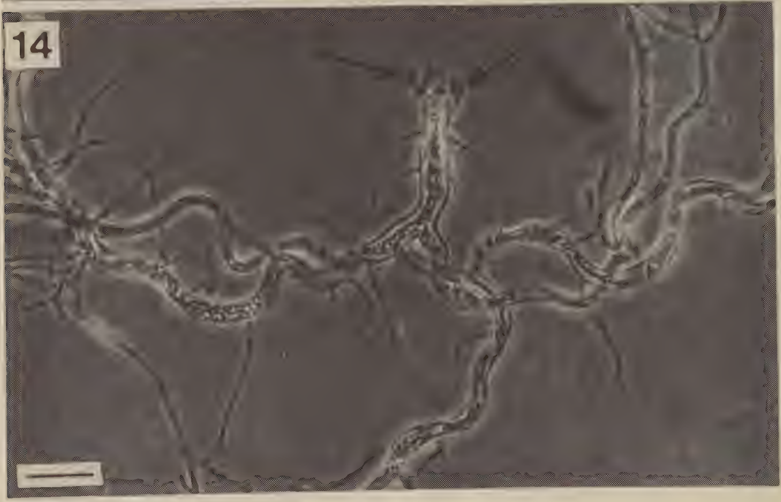


Fig. 13. Zoospores in a cluster or glomerule on the main rhizoid. Dissolution of the sporangial wall is so rapid that it is usually completed before the zoospores swim away. Fig. 14. Only tiny bits of basal sporangial wall are attached to the main rhizoid (arrows). The rest of the sporangial wall has dissolved. Bar = 20 μm.

All these characteristics separate *P. spiralis* from the other *Piromyces* species described and thus require it to be assigned to a new species.

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Notes on Tropical and Warm Temperate Basidiomycetes. II

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Summary

New taxa - *Coralloderma guzmanii* sp. nov., *Laxitextum bicolor* var *luteoalba* var. nov. and *Podoscypha semiresupinata* sp. nov. A possible new taxon in *Coralloderma* is discussed.

New records - *Dichopleuropus spathulatus* and *Vararia dussii* from Brazil; *Lopharia papyrina* from Bolivia.

Synonyms - *Lloydella rickii* Bres. = *Stereum illudens* Berk.

Additional notes on the morphology of *Lopharia sharpiana* are presented.

Coralloderma guzmanii sp. nov. (Fig. 1, d-g)

Differt haec species a C. acroleuca (Pat.) Reid *v. acroleuca sporis minoribus a C. acroleuca v. fibulata* Reid *fibulis nullis et a taxis ambibus hymenio amphigeno.*

Basidiocarpus ad 3 x 1.5 cm, stipitatus, spathulatus; in vivo carnoso-cartilaginosus, sordido-albus; in sicco fragilis, sordido-vitellinum basim nigricans. Hymenophorum amphigenum, dealbatum, sordido-vitellinum, fuligeneum. Stipes in sicco niger plus minusve complanato-striatus, hypharum 3-5 µm in diam tenuitunicarum confertarum ; superficies hypharum ramosissimarum ramis cortis intertextis, ominibus incrustatis nigribus.

Pileus in sectione fuscata; hyphae in fasciculis radiantis nonnihi agglutinatis tenuitunicatis particularis nigribus incrustibus, fibulis nullis, pallescentes agglutinatesque in hymenio spissecenti; hymenium gloeocystidiis, cystidiis et paraphysibus destitutis; basidia 45-54 x

5.5-7.2 µm, clavato-cylindrica duobus sterigmatibus ca. 9 µm longis, carnoso-arcuatibus.

Basidiosporae 5 - 11 x 3.5-7.2 µm (x = 7.2 x 5.4 µm), hyalinae, -IKI, guttulatae, aliquae collapsae. In solo crescenti.

Holotype: A.L.Welden 4004, in Hule plantation near Tuxtepec, Oaxaca, Mexico, on road to Jalapa de Diez, 3 Aug 1976 (NO).

The note on this collection identifies it simply as *Stereopsis radicans*, indicating that in the field it was reminiscent of that taxon, i.e., somewhat fleshy and a dirty white color. There is no indication of a color change when handled, characteristic of some American species. Yet, in drying and in age, the three basidiocarps become sordid egg- or orange-yellow, with the stipe and pileus base turning a dull black. The most startling feature is the amphigenous hymenium. Both surfaces of the pileus have what has every appearance of a thickening functional hymenium. Although the hymenia are somewhat agglutinated and only a few partially collapsed basidia were observed, a large number of collapsed basidia and basidioles were present on both surfaces, as well as an abundance of spores. There is no way to determine the developmental history of these specimens but, since they were growing on soil, it is unlikely that the pilei were rotated after one side became fertile.

The reference to *Stereopsis* is not a far-fetched one. The spores and basidia, several of which contain oil-like droplets and have fleshy sterigmata, are similar to those of the species in *Stereopsis*. The spores have a similar shape, a blunt apiculus, often guttulate, and tend to be irregular in outline because of their partial collapse. The variation in spore sizes indicates the presence of basidia with a variable number of sterigmata, also characteristic of *Stereopsis*.

Coralloderma is a poorly known genus. Only four collections were available to Reid for his studies (1965). Of these only Corner's collection of *C. acroleucum* v. *fibulatum* Reid was of a relatively recent date. One distinguishing feature of the genus is a cutis composed of erect interwoven hyphae. The taxon described here lacks that feature because of its amphigenous hymenium, but its stipe is covered with such hyphae. If we have a truly clavarioid *Coralloderma*, it may be representative of an ancestral form (Corner, 1954). Considering the basidial mechanism, it is improbable that a mycelium producing a dorsiventral flattened to infundibuliform pileus with protected basidia would give rise to one producing exposed basidia.

A collection made by Prof. Corner in Trinidad most likely represents another taxon in this genus. Unfortunately this collection is now fragmented. With permission, Prof. Corner's extensive notes are reproduced below. I have also made drawings of the microscopic features. It differs from *C. acroleucum* in its smaller spores, small sessile-spathulate pileus, and its habitat on bamboo. It is similar to *C. guzmanii* in spore size but differs by its unilateral inferior hymenium. However, the outer layer of the pileus is of thick-walled, obtuse hyphal ends. Might these be exemplars of an aborted or rudimentary hymenium ?

Coralloderma sp. (Fig. 1, h-j)

Pileus -23 mm in radius, 20 mm wide, spathulate then narrowly flabelliform, ascending, sessile, dull black, matt; margin pallid fuscous, entire; hymenium dark fuligenous to blackish, drying paler and fuscous toward the margin; flesh 1-1.2 mm thick, without tomentum, blackish, rather tough. Odor not distinctive.

In section with a slight abhymenial crust of agglutinated interwoven hyphae subtending a dense layer 25-40 µm thick of brown, thick-walled, obtuse hyphal ends, simple or ± lobulate; context with looser construction, tissue drying brittle and impossible to tease out; hyphae monomitic, apparently without clamps, not inflated, 2-4 µm in diam, walls thin or slightly thickened, with thin and discontinuous purplish black resinous incrustations insoluble in KOH, radiating and interwoven, somewhat agglutinated in fascicles, paler and agglutinated in the thickened hymenium; hymenium -33 µm thick, in 3-4 layers, covered by a dark purplish brown resinous deposit; basidia collapsed, evidently 2-4-spored; hyphidia, cystidia and gloeocystidia none.

Spores 7-8.5 x 4.5-6(-8) µm, white, smooth, broadly ellipsoid or ovoid-lacrymoid, rarely subglobose, thin-walled, much collapsed in drying, not amyloid.

On dead bamboo stump, Trinidad, W.I., E. J. H. Corner, s.n., 10 Oct 1947.

Dichopleuropus spathulatus Reid, Beih. N. Hedw. 18: 330. 1965. (Fig.1, a-c)

Basidiocarp -30 mm tall, pleuropodal, unipileate, ceraceous-brittle; pileus subflabelliform, folded abhymenially from the margin toward the base but not fused, forming a hollow at the pileus-stipe junction, ca. 10 mm wide; upper surface faintly zonate with brownish orange zones, darker at the base and margin; lower surface pinkish brown, smooth or very faintly zonate (drying ?), decurrent for a short distance; stipe 20 x 2-2.5 mm, slightly wider at base and at pileus, subtomentose, irregularly subreticulate, especially toward the pileus, pale grayish white.

Pileus devoid of cutis and epicutis; context dimitic with generative and binding hyphae; generative hyphae 1.5-5.5 µm in diam, thin-walled, simple septate, more closely packed adhymenially; binding hyphae abundant, faintly dextrinoid, in form of dichophyses the main body of which -5 µm in diam, giving rise to dichotomizing branches with long internodes that taper to 1 µm in diam; stipe filled with dichophyses, 2-5 µm in diam, slowly dextrinoid and generative hyphae with irregularly enlarged segments -6.5 µm in diam, filled with oil-like material.

Hymenium thickening -315 µm, infiltrated with dichophyses at its base but otherwise free of dichophyses; gloeocystidia arising within the context, subhymenium, and hymenium, cylindrical, 6-12 µm in diam, some with an inflated base, apices obtuse or rarely tapering to a ± acute tip, thin-walled, irregularly filled with refractive oil-like material or bacilliform rods, or both, traversing the hymenium beyond which they sometimes protrude slightly, abundant, sulfo-benzaldehyde negative (SA -); basidia 54-78 x 7-11 µm, cylindrical-clavate with (3-)4 sterigmata, mostly collapsed toward the base; basidioles similar; hyphidia (?) may be represented by narrow, cylindrical hyphoid structures.

Spores 5.5-9 x 6.5-7.5 µm (av. 11 = 7.4 x 6.7 µm, e = 1.1), globose to subglobose, smooth, hyaline, often guttulate, faintly, if at all, reacting to IKI, with noticeable but not conspicuously thickened wall, many embedded in the hymenium.

Brazil, north of Chavantina, Matto Grosso, E.J.H. Corner, s.n., 29 Jan 1968.

Professor Corner's specimen was provided with copious notes, which have been incorporated into the description. This is the first report of this species from South America. It is now known from Malaysia (Reid, 1965; Corner, 1965), Florida (Welden, 1971), and Brazil. The Brazilian collection consists of two basidiocarps. It differs from previous descriptions in four ways: (1) no dichophyses on the abhymenial surface, (2) no dichophyses in the hymenium, (3) no zonation in the pileus flesh, and (4) nonamyloid or faintly amyloid spores. The lack of zonation in the flesh may offer a clue to understanding these differences. In stereoid fungi the context zones represent periods of cessation of growth followed by regrowth and can be correlated with the pronounced zonation of the pileus. The lack of these zones would argue for the rapid growth and expansion of the pileus without intervening "rest" periods. Work with *Lopharia, Asterostromella,* and *Aquascypha* (Welden 1967a, 1975), among others, shows that there are alternate periods of hymenial growth. The probable sequence of development is first the hymenium develops and is then invaded by dichophyses or other sterile structures as ambient conditions become unfavorable for basidial development. If the invasion occurs while the hymenium is still active, the morphogenetic factors in the hymenium are enough to affect the size and shape of the sterile structures (Corner, 1948; Welden, 1966). As basidial development declines, the sterile structures may overgrow the old hymenium from the context or by differentiation of hyphae in the subhymenium or hymenium. With the return of favorable conditions the process may be repeated. The failure of the spores to react strongly to Melzer's solution may also be attributable to the youth of the Brazilian collection.

All basidia were collapsed in their lower third and their exact shape could not be determined. Only one was seen indubitably attached to its parent hypha, and it was collapsed also. Many species with dichotomizing hyphae have ventricose-cylindrical basidia. The narrow cylindrical hyphae often found in the hymenium, the "hyphidia" of the description, may be very young basidioles but to decide this was impossible.

Laxitextum bicolor (Pers.:Fr.) Lentz f. *luteoalba* f. nov.

A Laxitextum bicolor f. bicolor colore luteolo ad ochraceoleuco differt.

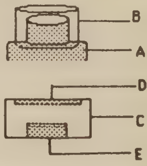
Holotype: on dead wood of *Salix*, batture of the Mississippi River, Jefferson Parish, Louisiana, A.L.Welden, s.n., 3 Aug 1969 (NO).

Paratypes: On fallen trunk in forest, Iquitos, Peru, E.J.H.Corner, s.n, 7 Apr 1948; on fallen wood near Wallace, Livingston Parish, Louisiana, A.L. Welden, s.n., 23 Aug 1960. All in NO.

Lentz (1955) erected *Laxitextum* to accommodate those resupinate to effuso-reflexed stereoid fungi with spongy-fragile to spongy-coriaceous texture caused by the loosely interwoven context of ± thin-walled hyphae. Boidin (1958b) restricted the genus to its type, *Thelephora bicolor* Pers.:Fr. Two other taxa included by Lentz, *T. roseocarneum* Schw. and *T. crassa* Lév. he removed to *Lopharia*. Welden (1975) followed Boidin's lead, but Larsen and Gilbertson (1977) considered *T. roseocarneum* a member of *Dendrocorticium*, while Burdsall (1985) tranferred *T. crassa* to *Phanerochaete*. Finally, Hjortstam and Ryvarden (1981) have described two additional taxa, *Laxitextum incrustatum* (illustrated as *L. incrustans* in their Fig. 1) and *L. lutescens*; the former from Africa and Louisiana, the latter from Africa. Both taxa are characterized by cream to deep yellow adhymenial surfaces, as opposed to white or off-white in *L. bicolor*. *Laxitextum incrustatum* is resupinate and *L. lutescens* is resupinate to reflexed with a deep yellow to pale brown, velutinate pileus. *Laxitextum lutescens* is said to have distinctly amyloid gloeocystidia, while these are only slightly amyloid in *L. incrustatum* Each differs slightly in spore size.

Among Prof. Corner's collections from Mexico and South America were two collections labelled *Laxitextum bicolor* and *L. bicolor* var.? The latter is a "yellow" form quite similar to two collections I have made in

Louisiana and one in Costa Rica (Welden, 1971). One of the Louisiana collections was put into culture in 1970 (the 3 Aug collection) and its mating type determined to be heterothallic tetrapolar. Using a technique of Tamblyn and DaCosta (1958) modified by Warcup and Talbot (1962), a dicaryon mycelium was grown in coarse elm (*Ulmus americana* L.) sawdust in a glass jar covered at its top by another, smaller glass jar (see adjacent figure), the whole placed into a terrarium with a shallow layer of water through which air was bubbled. When the mycelium had completely invested the sawdust (about three weeks), a block of Balsa wood cut to fit snugly over the neck of the larger jar was substituted for the smaller jar and watered daily by means of a depression cut into the upper surface of the block. Approximately one month later basidiocarps began to form and continued to do so for some time. These basidiocarps were similar in all respects to the original parent collection and produced abundant viable spores. Unfortunately, before suitable mating types of a typical *L. bicolor* could be obtained, the "yellow" culture was lost. The "yellow" form is not common and no additional cultures have been made. However, these results do demonstrate that the form is viable, true breeding, and has a mating pattern similar to the typical form. Its cultures are oxidase positive with gum guaiac using the method of Nobles (1958).



A. Glass bottle; B. Small glass bottle inverted; C. Balsa wood block; D. Upper water resevior; E. Cut-out to fit over larger bottle.

In its morphology the "yellow" form is similar in all respects to a typical *L. bicolor* f. *bicolor* except in color and in overall appearance in texture, which seems softer and, perhaps, less robust. The mycelium in culture, however, is vigorous. The Peru and Louisiana specimens are decidedly effuso-reflexed to reflexed with well-developed, unicolorous zonate pilei. One Louisiana specimen has more orange in its adhymenial surface than the others. None have amyloid gloeocystidia. Spore sizes in these specimens are as follows:

Iquitos specimen: 2.5-4.5 x 2-3 µm (av. 20 = 3.7 x 2.4 µm, e=1.5).
Louisiana specimen: 1969: 3.6-4.5 x 2.7-3.1 µm (av. 10 = 3.9 x 2.7 µm, e= 1.4)
Louisiana specimen 1960: 2.5-4.5 x 2-3 µm (av 40 = 3.5 x 2.5 µm, e=1.4).

Most gloeocystidia, which vary in quantity from specimen to specimen in both typical and "yellow" forms, have what Boidin *et al.* (1975) are pleased to call schizopapillae. When present, the papilla appears as a small bulbous extension at the tip of the gloeocystidium. The contents of the gloeocystidia vary in appearance from oil-like liquid to fat-like solid. Some oily contents may look frothy or granular. Similar oil-like substances occur in some of the hyphae, particularly those adjacent to the subhymenium. The contents frequently escape and appear on and in the hymenium as variously shaped droplets. When stained with Sudan IV these droplets, as well as the gloeocystidial and hyphal contents become orangish pink and may, therefore, be interpreted as fat or fat-like compounds. This material may be wholly or partly responsible for the adherence of the spores into a membrane-like structure covering at least part of the hymenium in some specimens. A similar reaction was detected in the gloeoplerous hyphae of *Clavicorona pyxidata* (Fr.) Doty. Interestingly, those hyphae react positively to sulfobenzaldehyde while those of *L. bicolor* and its variant do not. It may prove interesting in the future to pursue this reaction in other gloeocystidial species.

In summary, the "yellow" form of *L. bicolor* discussed here does not differ significantly in its morphology, cultural characteristics, or mating behavior from the typical form. It is similar in color and spore size to the taxa described by Hjortsam and Ryvarden but lacks the amyloid gloeocystidia of *L. lutescens* and the incrusted hyphae of *L. incrustatum* Whether a particular specimen is resupinate, effuso-reflexed, or reflexed does not appear to be of any particular import. Because of its similarities to, and its geographical overlap with, *L. bicolor* f. *bicolor* and its proven viability, the minimal interpretation of its relationship within the genus is the preferred one and serves to call attention to this unusual taxon.

Lloydella cinerascens (Schw.) Rick (Rick, s.n., São Leopoldo, Brazil, 1907, Caixa 113 in Herb. Rick, Mus. Nac., Rio Janiero) and *L. wrightii* Bres. [Rick 247 (or 418), São Leopoldo, Brazil, 1912] are examples of the cosmopolitan taxon *Lopharia cinerascens* (Schw.) G.H.Cunn.

Lloydella rickii Bres.

An examination of a portion of the type (Rick 369, São Leopoldo, Brazil) reveals that the spores are hyaline, smooth, thin-walled, inconspicuously apiculate, and 6.3-7.2 x 3.6 µm (six observed that were caught in the epicutis). There are acanthophyses and sulfobenzaldehyde negative pseudocystidia in the hymenium. The specimen is an old one and in parts more heavily pigmented than other specimens I have seen. However, it is a perfectly good example of *Stereum illudens* Berk. (Welden, 1967b).

There is an additional unreported specimen from Munchique, Cauca, Colombia, A.L.Welden, s.n., 5 Jul 1968 (NO). The species is now known to occur in Brazil, Colombia, Guatemala, Mexico, and Australia.

Lopharia papyrina (Mont.) Boid., Bul. Mens. Soc. Linn. Bot. Lyon 28: 210. 1959.

Specimen examined: Santa Cruz de la Sierra, Bolivia, E.J.H.Corner 62/48, 24 Mar 1948.

This collection extends the range of this taxon further south. It occurs northward as far as Dade County (Miami), Florida and is a typical member of the neotropical mycota.

Neither spores nor basidia were observed, but the effuso-reflexed, brown (grayish in age), zonate, tomentose pileus is characteristic. The pileus extends -12 mm beyond the substratum, the resupinate portion is indeterminate in growth. Renewed growth shows new pileus formation from beneath the older one in the same manner as in *L. sharpiana*, q.v. The lower surface is strongly setulose under the lens and reported by the collector as vinaceous fawn to purplish brown near the margin. Now it is concolorous with the other parts. All parts are coriaceous-spongy. Microscopically the collection is quite similar to others.

Lopharia sharpiana Welden, Tulane Stud. in Zoöl. & Bot. 17: 18. 1970.

Pileus effuso-reflexed, -9 x 2.5 cm, spongy-coriaceous; upper surface deep cinnamon, matt, azonate or inconspicuously zonate, covered with a dense tomentum in new growth, crust-like in older weathered parts; lower surface off-white with brownish margin, or concolorous but with rosaceous-gray areas, smooth; margin even, somewhat swollen.

In section 0.5-1 mm thick, soft, consisting of epicutis (tomentum), cutis, context, hymenophore, subhymenium, and hymenium; epicutis of densely but loosely interwoven lightly to darkly pigmented hyphae ca. 4-6 µm in diam that may be agglutinated toward their tips, arising from a cutis of tightly interwoven thick-walled coralloid pigmented hyphae; context of ± loosely interwoven skeletal and generative hyphae; the former thick-walled or with occluded lumina, pigmented, -470 x 3-6 µm, some turning into the hymenium as pseudocystidia, the latter thin-to thick-walled, hyaline, clamped, 1-4 µm in diam.

Hymenium thickening; subhymenial hyphae 2-3 µm in diam, hyaline, thin-walled, clamped, highly ramified, young cystidioids sometimes present in thickening hymenium, unencrusted; basidia 30-50 x 3.5-5.5 µm, long cylindrical clavate, 4-sterigmate, each sterigma ca. 3.5-5 µm long, straight.

Spores 4.5-7.2 x 2.2-3.6 µm (av. 11 = 6.1 x 2.8 µm, e = 2.1), cylindrical, hyaline, smooth, inconspicuously apiculate, IKI-.

Specimens examined: Mexico: Desierto de los Leones, E.J.H.Corner 23 & 27 Nov 1945; Souza 14, 1 Sep 1953; Tapia 20, 9 Aug 1959 (Corner 23 Nov & Souza at 2900 m alt.); Cerro de las Cruces, Ruiz 34, 5 Oct 1958 at 3000 m alt.(NO)

In its zonation *L. sharpiana* closely approaches *L. cinerascens*. No other presently known *Lopharia* has a cutis and epicutis. Among other distinctions, the coralloid cutis of *L. sharpiana* sharply separates it from *L. cinerascens*.

The holotype from Michoacan, Mexico was on coniferous wood, as was Corner's 27 Nov collection. The elevations reported for the others are within the conifer belt, and it is not unreasonable to infer that *L. sharpiana* is strongly associated with, if not restricted to, coniferous wood in the tropics.

Growth of the pileus is flabellate modified by ambient conditions. An earlier description (Welden, 1975) did not make clear how marginal expansion occurs. Either there is a distal elongation of the margin and concomitant hymenial formation and thickening, or a new pileus forms beneath the older one, or both may occur. Distal regrowth begins not simply as extension through the old margin but as an adhymenial outgrowth at a distance from the older margin. The new hymenium forms at the junction of the old and new pileus and proceeds distally. Posteriorly it joins with the new thickening hymenium of the older portions. Combined with the periodicity of the formation of the sporulating hymenium (see below), this manner of growth is responsible for the increasing stratose condition of the older portions of the fructification. On occasion, a new pileus may grow out from beneath the older one This seems only a modification of the method of growth described above, with new growth beginning not near the old pileus margin but from or near the site of emergence of the fruiting initial.

In a sporulating basidiocarp, the hymenophore, subhymenium, and hymenium are virtually free of the pigmented skeletal hyphae that have turned adhymenially. As sporulation is reduced, skeletals may invade this area and new skeletals develop within the area. Eventually, the formerly active hymenium will be overgrown by skeletals. Continued growth and a return to the sporulating condition will see the reëmergence of generative hyphae and new hymenium formation. Macroscopically, these changes, which are gradual, can be detected as color changes on the adhymenial surface from white or near white (active hymenium) through pale tan to brown or reddish brown. The thin-walled generative hyphae subtending the hymenium are tightly interwoven and highly branched. They impart a pseudoparenchymatous appearance to the region. Some of these give rise over time to skeletal hyphae.

An examination of other readily available species of *Lopharia* shows *L. mexicana* Welden, *L. papyrina* (Mont.) Boidin, and, perhaps, *L. cinerascens* (Schw.) G.H.Cunn. and *L. spadicea* (Pers.:Fr.) Boidin with a similar distal growth. Some of the other species have new pilei formed under the older ones.

Podoscypha semiresupinata sp. nov. (Fig. 2, g-m)

Differt haec species a allis species tomentosis anguste pileo effuso reflexo, sporis latioribus crassitunicatis et cute pileocystidiatisque deficientibus.

Pilei anguste effuso-reflexi, coriacei, separabilis, dorsifixi, origine parvi cremeo-ochracei separati dein confluenti ad 5 cm lati marginibus ad 4 mm latis; superficies tomento denso anguste; hymenium laevis, rugosis concentricis sparsisque.

In sectione cute deficenti; hyphae tomentosae fibulae longae intertextae crassitunicatae haud ramosae ad 6.6 µm in diam; hyphae contextae biformae aut aseptae haud ramosae tunicis crassis occlusisve ad 6 µm in diam aut ramosae fibulis et tunicis crassis v. incrassis.

Hymenophorum spissescentium; gloeocystidia clavata, cylindrico-clavata v. cylindrica hyphis fibuligeris exorienta, magnitudinis variabilis plerumque ca. 85 x 12 µm; basidia collapsa abunda ad 36 µm longis 4-steigmatibus, cystidiola ad 34 x 4.5 µm (versimiliter basidiola occluda).

Sporae 4.5-7.2 x 3-4.5 µm (av 40 = 5.5 x 3.9 µm, e = 1.4), hyalinae, interdum guttulatae, tenuitunicatae v. plerumque crassitunicatae, -IKI.

Holotype: Brazil, Corcovada, Rio de Janiero, 500 m alt, E.J.H.Corner, s.n., 19 Dec 1948. (NO)

The decidedly effuso-reflexed dorsifixed pilei with narrow densely tomentose margins, coupled with the lack of pileocystidia and cutis characterize this species. Each pileus begins as a small patch attached at one point and grows outward with its upper surface appressed to the substratum. Several adjacent pilei ultimately fuse at their margins and form a large fructification quite similar superficially to those seen in *Stereum*. The few species with which *P. semiresupinata* might be confused, e.g., *P. caespitosa* (Burt) Boidin and *P. glabrescens* (B. & C.) Boidin, differ in major ways from this taxon. The former, according to my notes on the type (Murrill 1181 in NY), has pilei that are only minutely tomentose, especially toward the base, and are attached by a stipe-like base with only a small resupinate portion. There is a distinct cutis that bears pileocystidia (dermatocystidia). Also, the spores on the average are

3.5µm in diam. In *P. glabrescens* there is a short rudimentary stipe and the tomentum, which is relatively inconspicuous, occurs only at the base. Again, the spores are also less than 3.5µm in this taxon.

Vararia dussii Boid. & Lanq., Mycotaxon 6: 292. 1977. (Fig. 3)

Basidiocarp resupinate, light cinnamon, rough to the touch, firm, with determinate margins, darkening in KOH, stratose in section with enclosed crystalline material in one or more strata and at the base. Generative hyphae 2 µm in diam with segments -4 µm in diam, clamped, often distorted and twisting into a pseudoparenchyma; dichophyses abundant, masking generative hyphae, branching 3-5 times, mostly with ultimate branches short, acute, curved to retorse, those toward or in the hymenial field shorter, bushier, often near or quite coralloid, main body 5-6 µm in diam, contextual ones with a narrower body and longer internodes, toward the base often long, approaching the dichophysoid hyphae of *Scytinostroma*.

Gloeocystidia sparse, ca. 18-28 µm long, ventricose-cylindrical, base 5-6 µm in diam, distal parts ca. 3.5-4 µm in diam, containing rod-like refractile material, sulfobenzaldehyde negative; basidia ca. 5-6 µm in diam, utriform, with 4 needle-like sterigmata each ca. 4 µm long; basidioles ± cylindrical, with basal clamp, 13-22 x 5 µm.

Spores 4.5-7.2 x 2.7-3.6 µm (av. 20 = 5.7 x 3.3 µm, e = 1.7), oval to cylindrical, thin-walled, smooth, hyaline, with a small apiculus, IKI-.

Specimens examined: Brazil: Manaus, Amazonas. E.J.H.Corner, s.n., 24 Oct 1948; Corcovado, Rio Janiero, on bark at base of living tree, 500 m alt., 2 Dec 1948, E.J.H.Corner 324. (NO)

According to Boidin and Lanquetin *V. dussii* may be distinguished by its long branching, contextual dichophysoid hyphae, relatively thick rust-colored to brown basidiocarp, clamped generative hyphae, curved tipped dichophyses, spore size, and sulfocystidia. The specimens reported here differ only in lacking SA+ gloeocystidia. The sulfobenzaldehyde reaction appears to be variable in some species and may be lost over time. This represents the second report of this taxon and is a significant extension of its range.

Acknowledgements

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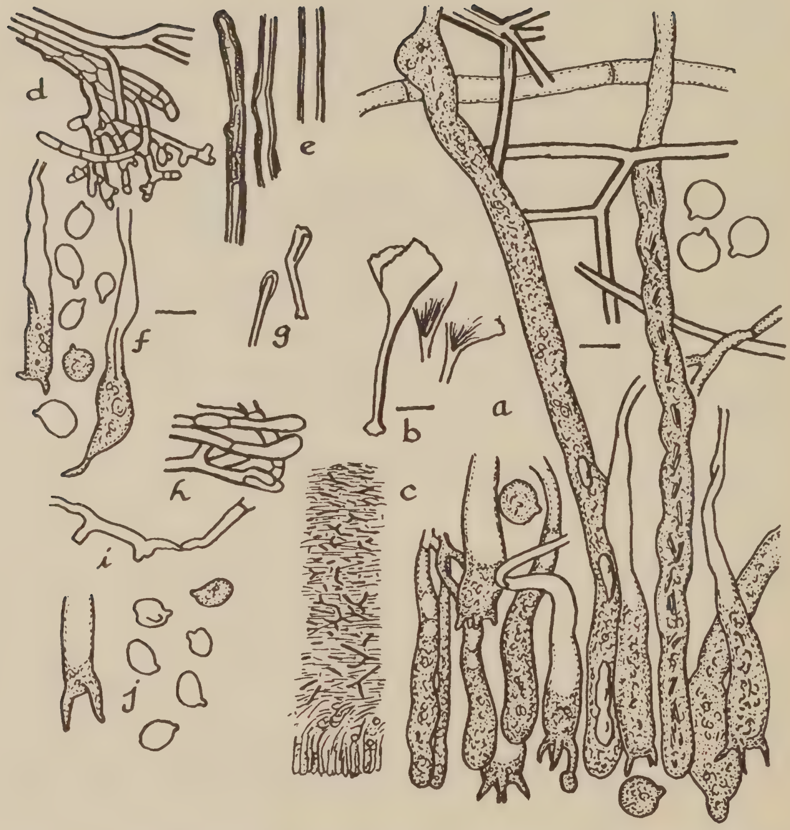

Fig. 1. a-c. **Dichpleuropus spathulatus**. a. Reconstructed hymenium with one young and three mature gloeocystidia, five basidia, two basidioles and a hyphoid structure (paraphysis ?), spores (some embedded in the thickening hymenium, dichophysoid hyphae, and generative hyphae. Line = 10µm. b. Habit with two side sketches showing marginal folding. Line = 1 cm. c. Schematic diagram showing the hymenium and upper surface free of dichophyses. d-g. **Coralloderma guzmanii**. d. Hyphae covering the stipe surface. e. Three stipe hyphae, one on the left from the surface, the others from the interior, both kinds with incrustation. f. One and two-sterigmate basidia, and spores. g. Habit. h-j. **Coralloderma** sp. h. Hyphae from pileus surface. i. Context hypha with simple septa. j. Basidium and spores. Line = 10µm.

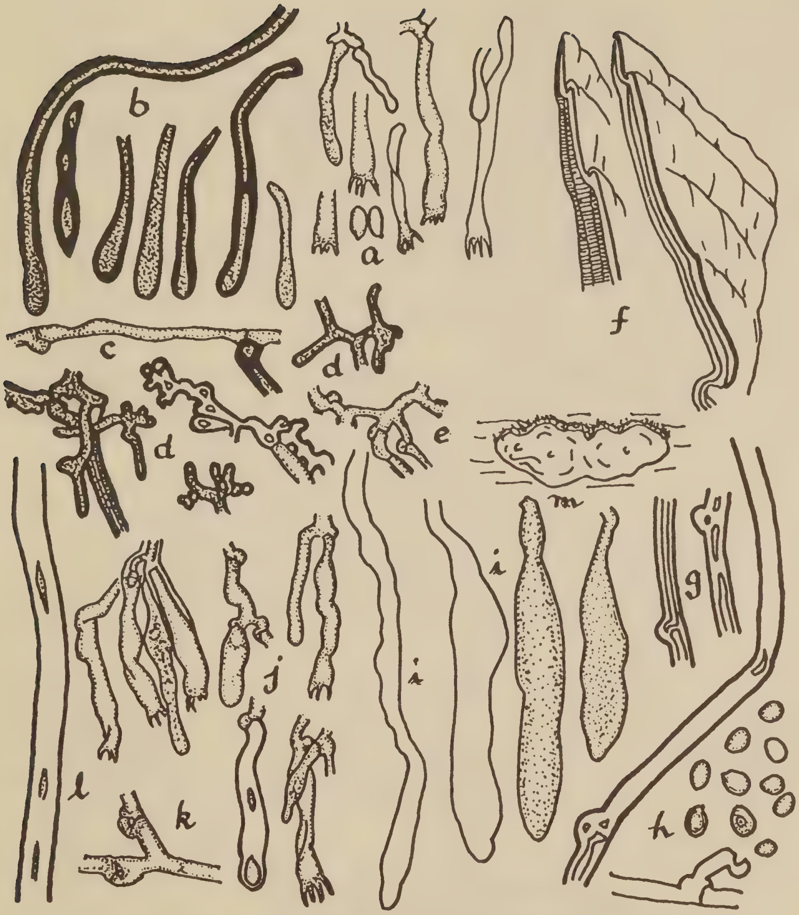

Fig. 2. a-f. **Lopharia sharpiana**. a. Basidia, basidioles, and spores. b. Thick-walled peudocystidia. c. Generative hypha showing the origin of thick-walled hypha. d. Coralloid hyphae from cutis. e. Generative hyphae with blackish incrustations. Line = 10 µm. f. Sketch showing manner of basidiocarp growth. g-m. **Podoscypha semiresupinata**. a. Thick-walled generative hyphae. b. Spores, one with a thickened wall, and a branching generative hypha. C. Gloeocystidia. d. Basidia and basidioles, and a thick-walled cystidium. e. Generative hypha. f. Skeletal hypha. Line = 10 µm. g. Habit.

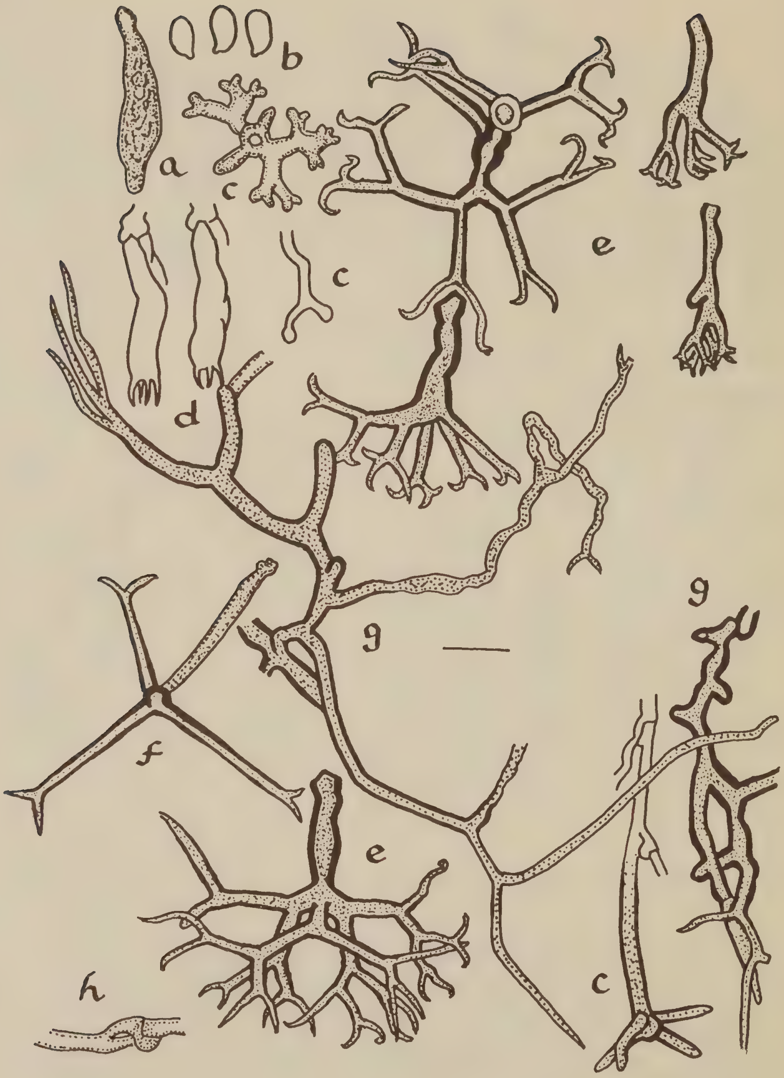

Fig. 3. **Vararia dussii**. a. Gloeocystidium. b. Spores. c. Very young dichophyses. d. Basidia, fourth sterigmata not shown on one. e. Mature dichophyses, the two short ones in the extreme upper right from the hymenium. f. Young asterophysoid hypha. g. dichophysoid hyphae from deep in the basidiocarp. h. Generative hyphae. Line = 7.5 µm.

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CORTINARIUS SYLVAE-NORVEGICAE SP. NOV. — A NEW SPECIES IN *CORTINARIUS* SUBGENUS *DERMOCYBE*

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SUMMARY

Cortinarius sylvae-norvegicae is described as a new species. It is related to *C. croceus*, but is separated from this species by larger fruitbodies and paler colours. The species is hitherto only known from Scandinavia where it seems to have an eastern to north-eastern continental distribution in rich and moist boreal forests. An emendated description of *C. croceus* is given. A lectotype for *C. croceus* is also proposed.

During field work in the autumn of 1991 in Sør-Trøndelag County, Central Norway, I became aware of an unknown species of *Cortinarius* subgen. *Dermocybe* bearing similarities to both *C. croceus* and *C. huronensis*, but with fruitbodies of strikingly larger dimensions and paler colouration. This finding inspired me to an investigation of herbarium collections labelled *C. croceus* which revealed some more specimens of the same fungus.

MATERIAL AND METHODS

Specimens seen (all specimens in Botanical Museum, University of Oslo):

Norway: Oslo County, Sørkedalen, Sinober, 23 Sept. 1979, open, rich, moist mixed forest, southern boreal zone, O.N. Bjørnstad and K. Høiland 502-79; Hedmark County, Folldal, east of Dalholen, Furuhovde, 4 Aug. 1980, rich birch-forest, northern boreal zone, T.E. Brandrud and K. Høiland 21-80; Buskerud County, Hole, Vik, 20 Sept. 1967, calcareous coniferous forest, southern boreal zone, G. Gulden 441/67; Sør-Trøndelag County, Meldal, Lake Urvatnet, by the cottage, 310 m a.s.l., UTM NQ 407 997, 1 Oct 1991, rich, swampy low-herb spruce forest with scattered birch, middle boreal zone, E. Bendiksen and K. Høiland K01191-1, K01191-2, and K01191-3 (holotype). Finnmark County, Vadsø, River Vestre Jakobselv (Annejåkka), between the waterfalls Førstefossen and Andrefossen, 3 Aug. 1979, upper inundation zone, lush birch-forest with small ferns, northern boreal zone, K. Østmoe and K. Høiland 210-79.

Sweden: Norrbotten County, Gällivare, Mt. Dundret, 16 Aug. 1981, rich, swampy mixed low-herb forest with birch and spruce, northern boreal zone, T.E. Brandrud and K. Høiland 35-81.

Preparations for the microscope were softened in 10% aqueous Aerosol OT solution and mounted in lactic acid. For each specimen ten mature, normally developed spores were measured by aid of an eyepiece micrometer and an oil-immersion objective (Zeiss, Ph 3, 100/1.25). I have used differences in length of 0.5 µm and have always omitted the apiculus. The spore measurements are given in the expression *(min)-avg*$\pm\sigma$*(n-1)-(max)*, where *avg* is the mean of 10 spores (given for each separate specimen, e.g. the type) or the grand mean of 10 spores for the whole material, σ*(n-1)* is the standard deviation, and *min* and *max* are the minimum and maximum values, respectively. The drawings of the spores were made by the aid of a camera-lucida with a Zeiss Planapo 100/1.3 oil-immersion objective.

All specimens were tested chemically for soluble pigments by means of thin layer chromatography. Powdered, small fragments of gill and cap trama were extracted with 96% ethanol for 15 minutes at 20°C. The extracts were spotted on precoated Merck 60 silica gel aluminium plates and developed with an eluent composed of ethylformiate:formic acid:toluene (50:15:35) saturated with water (Høiland 1984).

The colour code given for macroscopic characteristics follows Kornerup & Wanscher (1978).

DESCRIPTION

Cortinarius sylvae-norvegicae sp. nov. (Figs 1 and 2)

Pileus 2.2-7.9 cm latus, umbonatus vel convexus, tomentosus, haud fibrillosus, e olivaceo-luteo luteo-fuscus, margine olivaceo-luteo. Lamellae ochraceo-luteae, margine pallide luteo. Stipes 5.2-10.8 x 0.4-0.9 cm, saepe longus, fibrillosus, citrino-luteus vel pallide ochraceo-luteus, fibrillis luteis vel ochraceo-luteis, basi pallide olivaceo-luteola. Velum luteum vel ochraceo-luteum. Cortina pallide lutea. Caro pallide brunnea in pileo, pallide lutea, ochraceo-lutea vel luteo-brunnea in stipite. Sporae (6)-7.3±0.6-(9) x (4)-4.7±0.3-(5.5) µm, ovoideae vel amygdaloidae, raro ellipsoidae.

In piceetis vel betuletis in submontibus Scandinaviae.

Etymology of epithet: Mountainous birch forest with lush vegetation — which seems to be the most frequent habitat for the described species — is one of the most characteristic forest-types for Norway (Nordhagen 1943).

Type: E. Bendiksen and K. Høiland K01191-3, Norway, Sør-Trøndelag County, Meldal, Lake Urvatnet, by the cottage, 310 m a.s.l., UTM NQ 407 997, 1 Oct. 1991 (O, holotype).

Cap: 2.2-7.9 cm in diameter, convex to umbonate, felty to weakly fibrillose, sometimes somewhat silky, margin with very weak cortina rests, first pale olivaceous yellow (5C7), then yellow-brown (6D6-6E6), margin olivaceous yellow (5C7) and paler than centre.

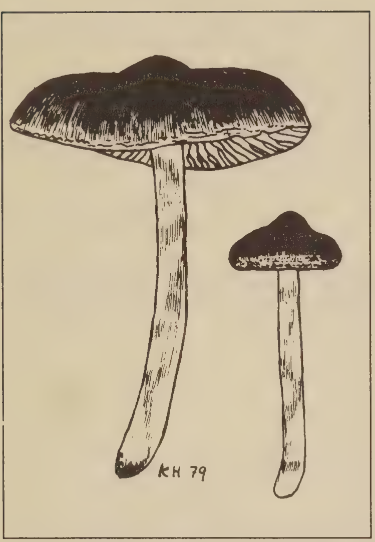

Fig. 1. Fruitbodies of *Cortinarius sylvae-norvegicae*, O.N. Bjørnstad and K. Høiland 502-79 (Oslo, Sørkedalen, Zinober.

Gills: 0.55-0.95 cm broad, first mustard yellow with an olivaceous tinge (4C8-4C7), then with a faintly orange tint (5C7), edge pale yellow.

Stipe: 5.2-10.8 x 0.4-0.9 cm, usually slender, fibrillose, silky, lemon yellow (3A5) to pale ochraceous yellow (5C6), with feeble, yellow (5C6-5D6) to yellow-brown (6D7) veil threads, base pale olivaceous yellowish.

Veil: Yellow to ochraceous yellow.

Cortina: Pale yellow.

Flesh: In cap pale brown (3C7, 4D7-4E7), in stipe pale yellow (3A6) to ochraceous yellow or yellow-brown (4C7-4C8, 5D7), with a weak smell of iodoform.

KOH-reactions: Cap cuticle red-brown, flesh pale red-brown. Gills red-brown. Stipe cortex carmine to red-brown, flesh red-brown.

Spores (6)-7.3±0.6-(9) x (4)-4.7±0.3-(5.5) µm, ovoid to amygdaloid, seldom ellipsoid, punctate, yellow-brown. Figure 2 depicts the spores in the type material.

Basidia: 18-22 x 5.5-6.5 µm, with 4 sterigmata maximum 4 µm long.

Gill edge: Fertile, with clavate, thin-walled, hyaline cheilocystidia, 15-25 x 6-7 µm.

Hyphae: Epicutis of parallel to somewhat interwoven, clamped hyphae, 3.5-13 µm broad, with brownish incrustation, yellow-brown; dark red-brown to yellow-brown, intercellular pigment lumps among the hyphae. Hypodermium slightly differentiated, of inflated hyphae up to 22 µm broad. Hyphae of gill trama 2.5-15 µm broad, hyaline to pale yellow, with bright yellow to orange, intercellular pigment lumps.

Pigments: Flavomannin-6,6'-dimethylether (much), endocrocin (traces), dermolutein (much), dermorubin (traces to little), and possible dermolutein or dermorubin glycosides.

ECOLOGY

Cortinarius sylvae-norvegicae is hitherto found either in mixed forests with spruce and birch or in pure birch stands, always on rich, moist ground, such as swamp forests by lakes or fens or inundated forests by rivers. The field vegetation is lush, often with ferns or herbs such as *Gymnocarpion dryopteris*, *Viola riviniana*, *Bartsia alpina*, *Filipendula ulmaria*, *Ranunculus repens*, and *Geranium sylvaticum*. Judged from the material at hand, the species prefers boreal forests, usually at higher elevations (middle to northern boreal zone), and it has an eastern to north-eastern continental distribution in Scandinavia.

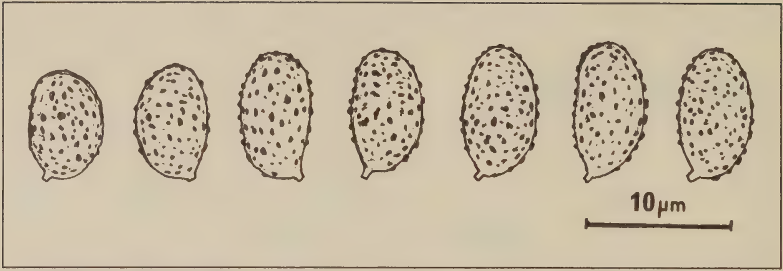

Fig. 2. Spores of *Cortinarius sylvae-norvegicae*, from the holotype, E. Bendiksen and K. Høiland K01191-3.

DISCUSSION

Cortinarius sylvae-norvegicae is a close relative to *C. croceus* (Schaeff.) S.F. Gray (see Høiland 1984) from which it differs by (1) the larger dimensions of the fruitbody, (2) paler gills, specially at the edge, and normally paler colours on cap and stipe, and (3) its ecology which seems to be restricted to forests with birch on moist, rich places. No special difference in pigment composition is seen between these two species. It could be tempting to consider the taxon a subspecies of *C. croceus*, separated by its morphology and different ecology. However, the size of the cap and the colour of the gills seem constant for *C. sylvae-norvegicae*, and I have not found any intermediates between the two taxa. Consequently it is regarded a species.

In the work by Høiland (1984), specimens belonging to *C. sylvae-norvegicae* have been included within the variation spectrum of *C. croceus* s.l. An emended description of *C. croceus* s.s. is therefore given: Cap: 1.4-4.5-(5.5) cm in diameter, convex to umbonate, felty to fibrillose or weakly squamulose, yellow-brown (5D7) to reddish brown (7D7-7D8) or hazel-brown (6E8-7E8), margin usually paler. Gills: Bright chrome- (4B8) to saffron-yellow (5B8-5C8), then usually with a rust-brown tint (5C8-6C8), edge concolourous or somewhat paler. Stipe: 3-7 x 0.3-0.7 cm, fibrillose, yellow (4A5) to pale ochraceous yellow (5C6), with yellowish to reddish brown veil remnants, sometimes as slanting belts. Spores: (5.5)-8±0.6-(9.5) x (3.5)-5±0.3-(5.5) µm, ovoid, ellipsoid or amygdaloid. This description is more in accordance with the neotype for *C. croceus* proposed by Høiland (1986), than with the wide interpretation of this species by the same author in 1984. The neotype was selected in an attempt to cover Schaeffer's (1774) original description of *Agaricus croceus*. However, this neotype is superseded by Schaeffer's (1762) colour illustration — Tab. IV "Agaricus qvartus" — which is referred to as *Agaricus croceus* by the same author in the mentioned protologue of 1774. According to Art 7.1, Int. Code Bot. Nom., 1988, this illustration represents the valid lectotype.

Cortinarius huronensis Ammirati & Smith var. *huronensis* is also reminiscent of the described species, but differs by its larger spores (Ammirati & Smith 1972). Its ecology is also somewhat different, since it prefers rather poor habitats in fens, swamp forests, or ombrotrophic bogs.

The cap and stipe colour of the described species comes close to that of *C. cinnamomeoluteus* Orton. However, the latter species deviates by its larger spores, usually umbonate cap, and ecology — always growing underneath willows or alder (Orton 1960, Moser & Keller 1977, Høiland 1984).

Acknowledgements

I am indebted to Dr. Thomas Kuyper, Biologisch station, Wijster, and Dr. Machiel Noordeloos, Rijksherbarium, Leiden, The Netherlands for critical review of the manuscript.

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— 1774. Fungorum qui in Bavaria et Palatinatu circa Ratisbonam nascuntur icones coloribus expressae IV. Index primus synonyma et auctores. — Ratisbonam.

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ALTERNARIA THEMES AND VARIATIONS (63-72)

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ABSTRACT

Choice of the correct name for the incitant of the *Alternaria* "black spot disease" of Japanese pear is considered. A core group of morphologically similar, toxigenic strains segregated from a working set of several hundred *Alternaria* isolates from pear lesions is selected to represent *A. gaisen* Nagano (syn. illegit. = *A. kikuchiana* Tanaka). Two nontoxigenic taxa encountered in the same working set are described as novel: *A. rhadina* E. Simmons and *A. arbusti* E. Simmons. A companion study of the sporulation patterns and the presence or absence of toxigenicity in the *A. gaisen* and other morphological segregates from the working set is presented concurrently in this issue of *Mycotaxon* (Simmons and Roberts 1993).

XI. *ALTERNARIA GAISEN* AND THE BLACK SPOT DISEASE OF JAPANESE PEAR

Introduction

A black spot disease very destructive to commercially valuable cultivars of *Pyrus pyrifolia* (N. L. Burm.) Nakai, particularly cv. Nijisseiki (20th Century), has been attributed consistently to named species of *Alternaria* since 1920 (Nagano).

The name *Alternaria kikuchiana* Tanaka (1933) is used customarily, but incorrectly, in current catalogues and indices to designate the incitant of the disease whenever the fungus is regarded as a distinct species. Current literature on host-specific toxins (Kohmoto and Durkin 1989; Scheffer 1992) usually treats the toxigenic taxon as morphologically indistinguishable from *Alternaria alternata* (Fries) Keissler.

Attempts to characterize the fungus and to untangle its nomenclature have been frustrated until recent years, not only because of the absence of type or author-related specimens but also because of the difficulty of assembling a study group of specimens and stable isolates from a fungus-related disease not yet known to occur outside of Japan and some neighboring countries of East Asia. (But see Lit. Cit.: Baudys et al., 1993 [published during editing].)

A survey of several hundreds of isolates from Japanese pear lesions from Japan, South Korea and Taiwan and from the U.S.A. (California, Maryland, Michigan) has supported this review of the identity and the nomenclature of the taxon.

Chronology and Disposal of Names Assigned to Taxa Associated with Black Spot Disease of Japanese Pear

Eight *Alternaria* and *Macrosporium* binomials appear in the literature of 1920-1936 on a fungus black spot or rot disease of a few of the several hundreds of Japanese pear and Chinese pear cultivars (also *Pyrus pyrifolia*). The authors of these names, discussed below, indicate in one way or another that they consider themselves to be dealing with a single disease and a single fungus taxon or, when they attempt to distinguish between similar diseases on Chinese pear and Japanese pear cultivars, two fungus taxa.

The name proposals, all in Japanese publications, represent a series of attempts to cope with opinions on legitimacy of earlier names, synonymy, and differences in host susceptibility. Only one, or possibly none, of the eight names can be maintained as correct when the authors consider that a single fungus taxon is the incitant of the disease on Japanese pear and if the taxon is distinguishable from similar taxa.

For the record, and as nearly as I can determine, no specimen exists that can be considered to have type value for any of the eight names, nor is any isolate extant that originated with any author at the time he published a name. Choice of a correct name must be based on the original literature considered under provisions of the codes of botanical nomenclature in force during the period 1920-1936.

More than usual attention is paid here to abstracting opinions on the disease and on associated fungus names. Aside from a nomenclatural justification, it is offered as a bibliography of pertinent literature that has been very difficult to compile. The extra attention here, it is hoped, will make any future verification of citations and translations by others less time consuming than has been my lot.

63. **1920** *Alternaria gaisen* Nagano
[Journ. Japanese Horticultural Society] 32(3): 16.

Nagano contributed a four-page, illustrated article (in Japanese) on a disease of several kinds of pear cultivars, including one called Gaisen. He assigned a common name, ring-spot disease of pear, emphasizing the presence of dark concentric rings in enlarging fruit lesions. Nagano examined the causal fungus under several conditions, confirmed it as belonging to the genus *Alternaria*, and named it "Alternaria Gaisen, Ngano" [sic].

Nagano described the evolution of lesions on fruit and young shoots (initial black spots spreading on the surface in the form of concentric rings), illustrated representative lesions (reduced from natural size) and conidia with conidiophores (enlarged from natural size), and described the fungus in terms of a surface layer of short conidiophores, above which conidia were produced and adherent; the conidia, falling off naturally, were black, long obclavate in form, with 5-6 transverse and 1-2 longitudinal septa. Conidium dimensions were not given.

Nagano published this name and description validly and included illustrations of the fungus, thus typifying the name. The name was not presented as a replacement for one published earlier; Latin descriptions or diagnoses were not required for new taxa in 1920; the absence of conidium measurements, though a hindrance, does not in itself render a name illegitimate.

The name *Alternaria gaisen* Nagano (1920), therefore, is legitimate. It is the correct choice of name when placed in competition with other names suggested for the *Alternaria* incitant of black spot disease of Japanese pear. The only name that, from a usage viewpoint, is in serious competition with *A. gaisen* is illegitimate *A. kikuchiana* Tanaka (1933, below).

64. **1925** *Alternaria nashi* Miura
[Orchard Management in Manchuria], p. 155, published as [Industrial Contribution no. 23, Agricultural Section, Industrial Department, South Manchuria Railway Co., Ltd.]

Miura reported briefly on a black rot disease of Chinese pear. He introduced a name "Alternaria Nashi Miura" in this report but gave no morphological details or illustrations of a fungus. The name is simply a nomen nudum, without other use in *Alternaria* nomenclature.

Tanaka (1933, p. 27) writes that Miura, in the place cited above, "named at first the causal fungus of the black rot of Chinese pears as *Macrosporium Nashi* Miura." This is not correct; no such name appears in the eight lines of Miura's short presentation.

65. **1925** *Alternaria gaisen* Nagano, in K. Hara [Handbook of Pathology of Crop Plants], p. 263 (fide Miura, 1928 below).
1928 Ibid., ed. 4, p. 263.

Reference to Hara's treatment of the black spot fungus is included here in chronological order for two reasons: that Miura (1928 below, p.513) listed "*Alternaria Gaisen* (Nagano,) Hara" in a discussion of pear diseases, giving the impression that Hara had created a name combination (which he had not done); and that Hara, in the several editions of his handbook, provided an early description of *A. gaisen*, a description as usable as most other *Alternaria* descriptions of the early years of the 20th Century.

Hara included a short chapter (in Japanese) on what he called black spot disease of pear, describing symptoms and lacquer-black lesions, and detailing characteristics of sporulation: conidiophores 8-10 in clusters, yellow-brown, 2-6 septate, 34-90 x 2-6 μm; conidia obclavate or pyriform, pale yellow-brown, 40-110 x 11-22 μm, with 7 transverse and a few longitudinal septa.

Hara's handbook of crop plant pathology went through four editions in the period 1925-1928. Tanaka cited none of these in his 1933 paper, although he did comment on a paper by Miura (1928 below) in which the 1925 edition of Hara's manual is cited. Tanaka's work merited expanded notes on the morphology of the fungus he was using, presumably *A. gaisen*, but it did not require a new epithet based on the name of his horticulture professor, A. Kikuchi.

[Bibliographic note: I have seen a copy of only the 4th edition of the Hara handbook. A publisher's note in the 4th edition lists June 24, 1925 for original issue; Nov. 4, 1925 for 2nd edition; Jan. 20, 1927 for 3rd edition; June 10, 1928 for 4th edition. Miura (1928) refers to "*Alternaria Gaisen* (Nagano,) Hara, in Handb. 263, 1925," the same page on which Hara's description of *A. gaisen* occurs in the 1928 edition.]

66. **1928** *Alternaria bokurai* Miura [as *Alternaria Bokurai* (Bokura) Miura]
[Flora of Manchuria and East Mongolia. Part III. Cryptogams, Fungi], p. 513; published as [Industrial Materials no. 27, Bureau of Agriculture, Industrial Department, South Manchuria Railway Co.]

Miura proceeded here to indicate his belief that the fungus causing the black rot disease of Chinese pear in Manchuria is the same as that causing the ring spot or black spot disease of Japanese pear in Japan. He swept all previous pertinent names together under a new binomial, "Alternaria Bokurai (Bokura.), M. Miura, n. sp." [sic].

At the risk of misinterpreting his intentions, it seems likely from the context of his synonymy that he considered one or two earlier reports by Bokura of a pear disease "*Alternaria* sp." to hold some sort of nomenclatural priority and his own novel *A. bokurai* , therefore, to be a legitimate and correct name for the fungus.

Miura's publication of *A. bokurai* broke rules of nomenclature, notably the rule forbidding citation of a previously published legitimate name as a synonym of a new name. The name *A. bokurai* is illegitimate. I have not seen the Bokura publications to which Miura refers: "*Alternaria* sp. Bokura, in Ex. St. Rpt. Dept. Ag. Nishigahara 1919, in l.c. 1918." The synonymy proposed by Miura illustrates his line of thought: **Alternaria bokurai** (Bokura) Miura; **Syn.** *Alternaria* sp. Bokura (1918, 1919), *Alternaria Gaisen* Nagano (1920 above), *Alternaria Nashi* Miura (1925 above), *Alternaria Gaisen* (Nagano) Hara (1925 above).

Miura (p. 514-515) gives an extended description (in English) of fruit and leaf lesions as well as details of conidium and conidiophore morphology. Tanaka (1933 below) makes the observation that Chinese pear material received from Miura is not pathogenic to Japanese pear cultivars known to be susceptible to the black spot disease and gives the opinion that two different species of *Alternaria* are involved.

67. **1928** *Macrosporium nashi* [without author, but in Miura] [Flora of Manchuria and East Mongolia. Part III. Cryptogams, Fungi], p. 514; published as [Industrial Materials no. 27, Bureau of Agriculture, Industrial Department, South Manchuria Railway Co.]

In discussion of *Alternaria bokurai*, Miura (1928 above) says that his original fungus on pear fruit had spores which were *Macrosporium*-like and that he at first used the name "*Macrosporium Nashi*" by way of a memorandum. Miura's *Macrosporium nashi*, like his *Alternaria nashi* (1925 above), is a nomen nudum and, in fact, never was published intentionally as a name for the pear disease fungus.

68. **1933** *Alternaria kikuchiana* Tanaka Memoirs of the College of Agriculture, Kyoto Imperial University, no. 28 (Phytopathology Series no. 6), p. 27.

Tanaka reports results of extensive study of the black spot disease, emphasizing physiological and cultural characters of the causal fungus. Tanaka's paper, in English with fungus description in Latin, is cited by an entire school of phytopathologist/physiologists as the first confirmed example of selective toxicity to a plant by culture filtrates, a class of agents currently referred to as host-specific toxins. Research on these toxins is summarized in a symposium volume edited by K. Kohmoto and R. D. Durbin (1989).

The Tanaka paper also serves as the source of the name, *A. kikuchiana*, most frequently used by mycologists and international culture collections for the Japanese pear black spot fungus.

Tanaka (loc. cit., p. 27) dismissed the work of Nagano (1920 above) with the observation that Nagano "published a brief note in Japanese, on the present disease and first proposed the new name *Alternaria Gaisen* Nagano for the causal fungus, giving no description of its important characters. Accordingly the name, *Alternaria Gaisen*, must be neglected in the scientific discussion." In disagreeing with this assessment, it is appropriate to point out that Tanaka failed to mention the professional acceptance of Nagano's species name and the very usable augmented description of *Alternaria gaisen*, including conidium dimensions, that was available in K. Hara's handbook of pathology (1925 above), which had gone through four editions in Japan before Tanaka's report of 1933.

Tanaka, writing in English and Latin rather than the Japanese of Nagano and Hara, made information on this fungus more accessible to mycologists worldwide. Nevertheless, his proposed name for the fungus, *A. kikuchiana*, was an avowed substitute for an earlier legitimate name of what he considered to be the same fungus, *A. gaisen*, and therefore is illegitimate. It represents an incorrect choice when used.

69. **1936** *Alternaria kikuchii* Tanaka, in Hara
[Injurious Fungi of Japan], p. 322.

No reason for the introduction of this superfluous orthographic variant of Tanaka's *A. kikuchiana* is given in the seven lines of Hara's descriptive text. The name is illegitimate.

70. **1936** *Alternaria manshurica* Hara
[Injurious Fungi of Japan], p. 323.

This name introduces a discussion (in Japanese) of the black spot disease of red pear [*ko* + *nashi*] as distinct from the disease caused by *A. kikuchiana* on Japanese pear [*nashi*]. Hara cites *A. bokurai* Miura in parentheses, presumably as a synonym, and includes both *A. bokurai* and *A. nashi* Miura in discussion. The apparent intent is to introduce a name with description (here in Japanese) to replace the two illegitimate Miura names insofar as they referred to red-skinned, presumably Chinese cultivars of the Asian pear.

Alternaria manshurica is considered to be typified by the illustrations of conidia and conidiophores that accompany the description. However, by 1936 a Latin description or diagnosis was required by rules of nomenclature for new names. Hara did not supply one. The name is illegitimate.

Hara introduced a slightly variant spelling, *Alternaria manschurica*, also illegitimate, in his List of Japanese Fungi Hitherto Known (1954, p. 14).

* * *

A morphologically distinct, toxigenic reference strain used by the foremost research group on the *Alternaria* toxin related to pear black spot (*Tottori 15A*, EGS 37-132, from Prof. K. Kohmoto, Tottori University Faculty of Agriculture) has served as a model for segregation of potential representatives of *A. gaisen*. Nineteen isolates selected as being morphologically identifiable with *Tottori 15A* proved to be toxigenic when tested against leaves of Japanese pear cv. Nijisseiki (Simmons and Roberts 1993). This core group of strains, all from Japan, South Korea, or Taiwan, serves to characterize *A. gaisen* in its strictest sense.

Alternaria gaisen Nagano Fig. 61

Representative isolates of *A. gaisen* grow and sporulate well on PCA, Hay, and V-8 agars in petri dishes that are not sealed against gas exchange, including loss of moisture (see "Conventions used" and "Media," in Simmons and Roberts 1993). Colonies reach about 3-4 cm. diam. within one week. The most stable recent isolates produce very little aerial mycelium. Well-defined concentric rings of abundant and less abundant conidiophore and conidium production alternate at radial increments of about 0.5 cm. Colony color, black to grey, is governed by the relative density of sporulation and by the absence or abundance of pale non-sporulating mycelium.

Less stable recent isolates and practically all isolates that have reached me on media richer in nutrients than those used here have varying amounts of non-sporulating aerial and surface mycelium, mostly in alternate growth rings. Cultures of such isolates shade into diffuse greys and often have less well defined rings, in contrast to the intense black and good definition of growth rings of highly sporulating isolates. Representative toxigenic isolate *Tottori 15A*, for example, has become abundantly mycelial and poorly sporulating over the years. A series of single-chain reisolations of this strain has yielded progressively better-sporulating cultures. Nevertheless, retention of considerable amounts of non-sporulating aerial mycelium in *Tottori 15A* (EGS 37-132.1) precludes its being chosen as a definitive representative of *A. gaisen*, even though it and its derivative isolates (EGS 37-132.2 and 37-132.3) have retained typical toxigenicity throughout this study.

Of the several *A. gaisen* isolates available and in good sporulation condition, one from a black spot lesion of a cv. Nijisseiki pear leaf, collected by me 11 July 1990 on the Tottori University campus, is stable, excellent in sporulation, and essentially devoid of nonsporulating aerial mycelium (EGS 90-051.2). It is used here in composing the following basic description of *A. gaisen*, mostly as studied on PCA after one week of growth.

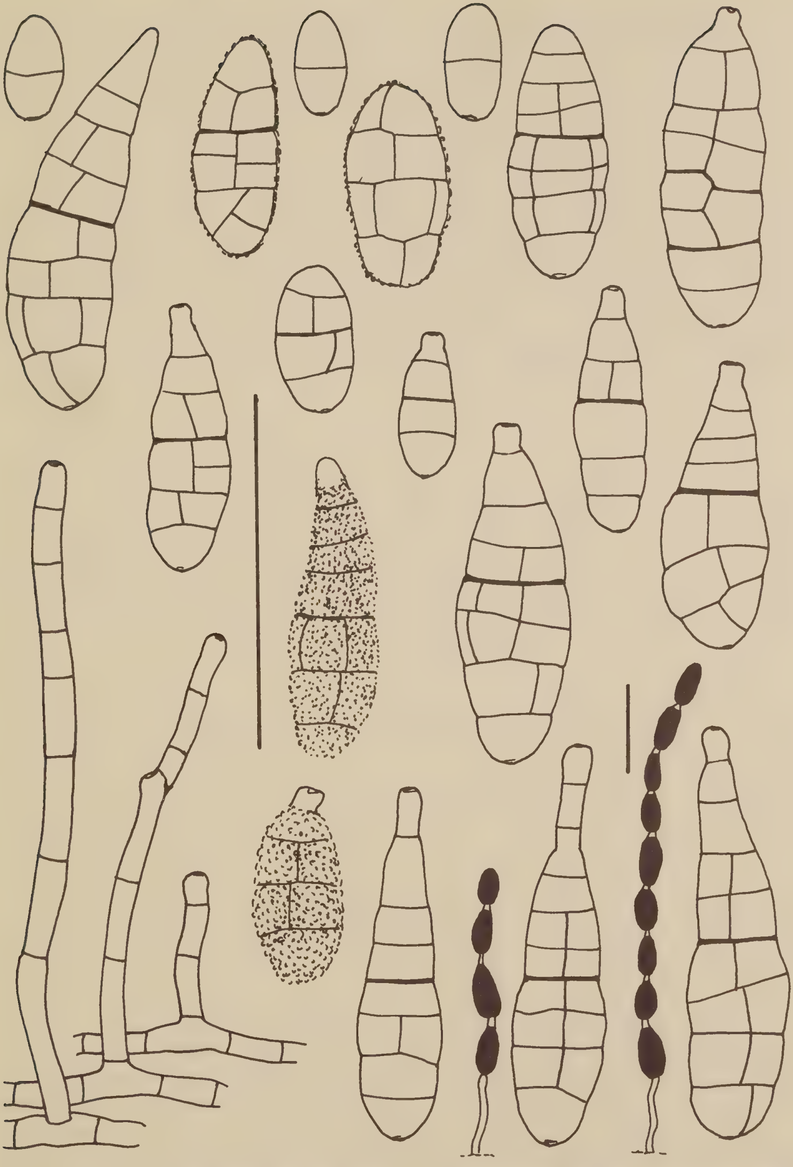

Fig. 61. *Alternaria gaisen*: characteristic conidia and primary and secondary conidiophores (line = 50 μm); characteristic sporulation pattern (line = 50 μm), conidium bodies opaque, conidiophores clear. EGS 90-051(2).

Primary conidiophores arise directly from subsurface and surface hyphae. These primary conidiophores are solitary, distinct to crowded on PCA, distinct and comparatively uncrowded on Hay, and so densely crowded and conidiogenous on V-8 as to be obscured in 50X viewing. Well-defined concentric rings of abundant and less abundant conidiophore and conidium production alternate at radial increments of about 0.5 cm. Conidiophores may sporulate when they are as short as 15-25 µm, but for the most part initial conidia are produced when conidiophores are (50-)80-150 µm long. Conidiophores become 3.0-4-5 µm wide, septate, dilute yellowish brown, unbranched or frequently once or twice geniculately branched. Aerial hyphae of less stable isolates sometimes produce conidiophores, or they may remain essentially devoid of conidiogenous branches.

To a very great extent conidia are produced in unbranched chains of 5-9 spores. In older, nearly central portions of a 10-day old colony, chains of 9-13 conidia also occur; but in most colony areas, especially those about five days old (i.e., about half way between center and circumference), the short chain character is the rule. Branching of chains also may be detected, usually as a lateral production of 1-2 conidia from a single spore of the primary chain; but in general lateral branching is uncommon.

Most conidia are short to long ovoid, sometimes ellipsoid. They may taper distally, particularly when the conidium body is long ovoid; but there essentially never is a discrete true beak area in conidia produced in culture. Instead, each conidium except the terminal one in every chain has an apical secondary conidiophore of one cell (uncommonly 2-3 cells, or even none when an apical pore functions in place of a morphologically distinct conidiophore). The origin of the secondary conidiophore usually is distinguishable as a break in contour and color between the conidium apex and the nearly parallel sides of the new conidiophore.

An eye-catching feature of slide mounts of *A. gaisen* conidia is the high percentage of fully developed, relatively broad (l/w ca. 2.0), beakless spores. The percentage, higher than 10%, is an indirect indication that somewhat fewer than 10 conidia make up most chains in a stable culture of the species. Approximately 5% of other conidia tend to be long ovoid and to have a more pronounced apical taper that usually terminates in a secondary conidiophore of several cells. This kind of long pseudorostrate conidium usually is the initial spore at the base of a chain and, even at 50X, has an aspect different from that of the essentially untapered, closely spaced conidia produced above it in the chain.

Most mature conidia are 30-45(-55) x 13-15(-18) µm, medium yellowish brown in color, almost smooth to conspicuously verruculose overall, with 5-8 transverse and 0-1, occasionally 2 longitudinal septa in each transverse segment. The initial median transverse septum becomes darker, thicker, and slightly more constricting than secondary transverse septa. Septa other than the initial median often are ill-defined and commonly are indistinct under an overlay of wall pigment and ornamentation. The basal pore through the conidium wall is not easily seen; the sort of pigmented basal halo found so commonly in conidia of many species of *Alternaria* usually is absent in *A. gaisen*.

Novel *Alternaria* Species from Japanese Pear Orchards

Two other taxa of the dozen or more morphologically recognizable in this study are easily distinguishable from all the others. Each is distinctive, not only within the context of pear orchard isolates but also within *Alternaria* as a whole. Both taxa are described below as novel. No isolate of either taxon has proved toxigenic under conditions of this study (Simmons and Roberts 1993). The type descriptions are based on colonies about one week old as produced on PCA. Type depositories, indicated in boldface capital letters, are as listed in Holmgren, et al. (1990).

71. **Alternaria rhadina** E. Simmons, sp. nov. Fig. 62

(Etym.: Gr. *rhadinos*, slender, tapering; a diagnostic conidium character)

Ex cultura in agaro PCA descripta. Conidiophora simplicia, solitaria, erecta, dilute brunnea, usque ad 60-110 x 3-4 µm. Sporulatio in catenis longis conidiorum 10-15+, ramis raris vel nullis. Conidia ovoidea vel longe angustiovoidea, erostrata vel rostro longe gradatim decrescenti, pallide straminea vel dilute avellanea, plerumque minute vel conspicue aspera, maturitate 35-43 x 11-16 µm (ovoidea) vel 55-90 x 8-9 µm (longe angustiovoidea, rostro incluso), 4-7 transverse et 0-4 longitudine septata. Habitatio typi in macula folii Pyrus pyrifolia cv. Nijisseiki, Nagano, Japan. Typus: partes ex cultura EGS 90-148(2) desiccatae et in **BPI** *(holotypus) et pro isotypus saltem in* **IMI** *conservandae.*

The culturally stable isolate of *A. rhadina* grows well

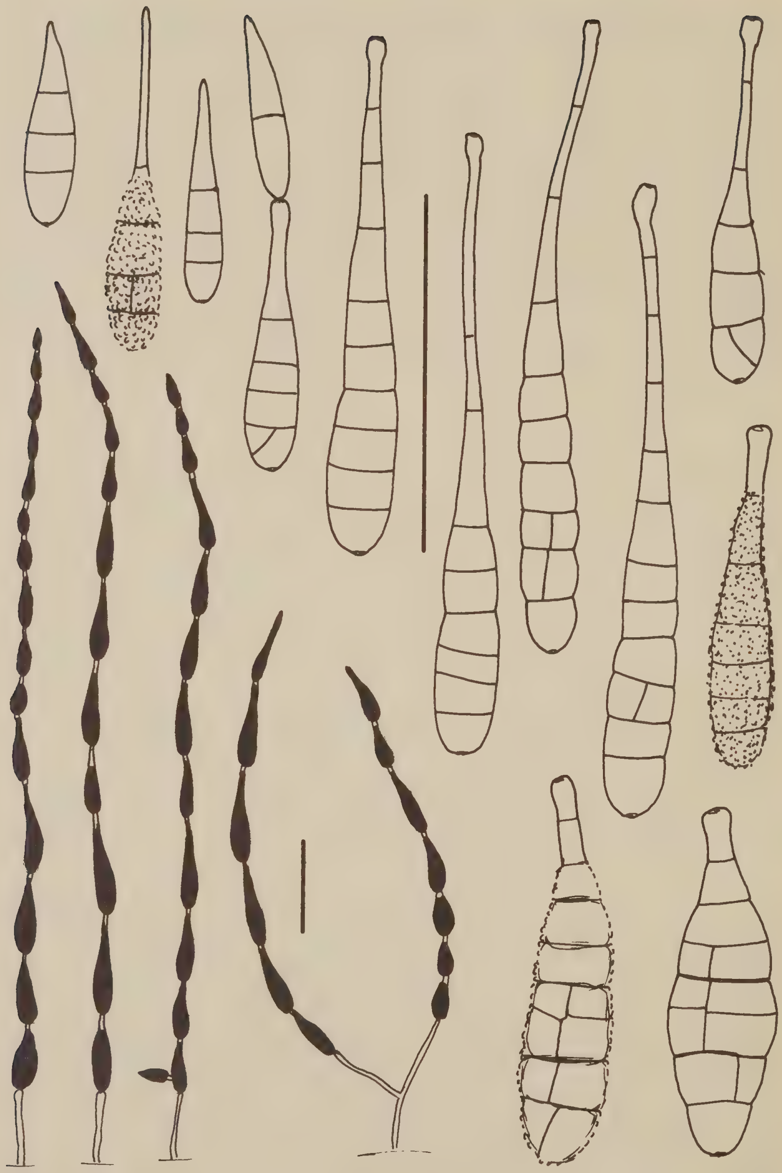

Fig. 62. *Alternaria rhadina*: characteristic conidia with secondary conidiophores (line = 50 μm); characteristic sporulation pattern (line = 50 μm), conidium bodies opaque, conidiophores clear. EGS 90-148(2).

and sporulates abundantly on the agars and under conditions specified earlier. Primary conidiophores are produced abundantly but uncrowded from surface and subsurface hyphae; nonconidiogenous aerial mycelium is absent. The 50X aspect is of great numbers of closely spaced but distinct, long, narrow, erect or variously inclined chains of 9-15 conidia.

Primary conidiophores, viewed at higher magnifications, are simple, erect, dilute brown, up to about 60-110 x 3-4 µm. Initial conidia in chains may be ovoid with an apical 1-cell secondary conidiophore or narrowly ovoid with a narrowly tapering beak terminating in a slightly swollen conidiogenous cell. Each chain typically includes both kinds of conidia in its development, although the long-tapered ones predominate and contribute most to the diagnostic appearance of a chain. Conidia at maturity are mostly pale stramineous to dilute brown in color; smooth-walled (rarely), inconspicuously punctulate (usually), or conspicuously verruculose (often); 35-43 x 11-16 µm (ovoid) to 35-45 x 8-9 µm (narrow ovoid) + 20-45 µm (tapered beak); 4-7 transeptate (spore body) with 1 longitudinal septum in each of 0-4 of the transverse compartments. Conidium chains usually are unbranched; branches, when present, usually originate in a basal conidium of the primary chain and consist of only 1-2 conidia.

The only example of *A. rhadina* known to me is the single isolate from which holotype and isotype specimens were prepared: EGS 90-148(2), isolated from a black lesion with a pale halo in a leaf of *P. pyrifolia* cv. Nijisseiki, coll. 18 July 1990, Nagano, Japan.

72. **Alternaria arbusti** E. Simmons, sp. nov. Fig. 63

(Etym.: L. *arbustus*, orchard; as habitat)

Sporulatio in catenis curtis conidiorum 3-6, ramis raris vel nullis. Conidia matura ovoidea (25-40 x 9-17 µm) vel longiellipsoidea (38-56 x 10-16 µm), erostrate autem saepe pseudorostro cellularum 1-5 (5-40 x 4-5 µm), sublaevia, olivaceo brunnea, 3-8 transverse et 1-4 longitudine septata; septa manifeste badia. Habitatio typi in macula pallide ferruginea folii Pyrus pyrifolia, Loomis, California, U.S.A. Typus: partes ex cultura EGS 91-136 desiccatae et in BPI (holotypus) et pro isotypus saltem in IMI conservandae.

Cultures of *A. arbusti* closely resemble those of *A. gaisen* in initial 50X examination, in that sporulation occurs

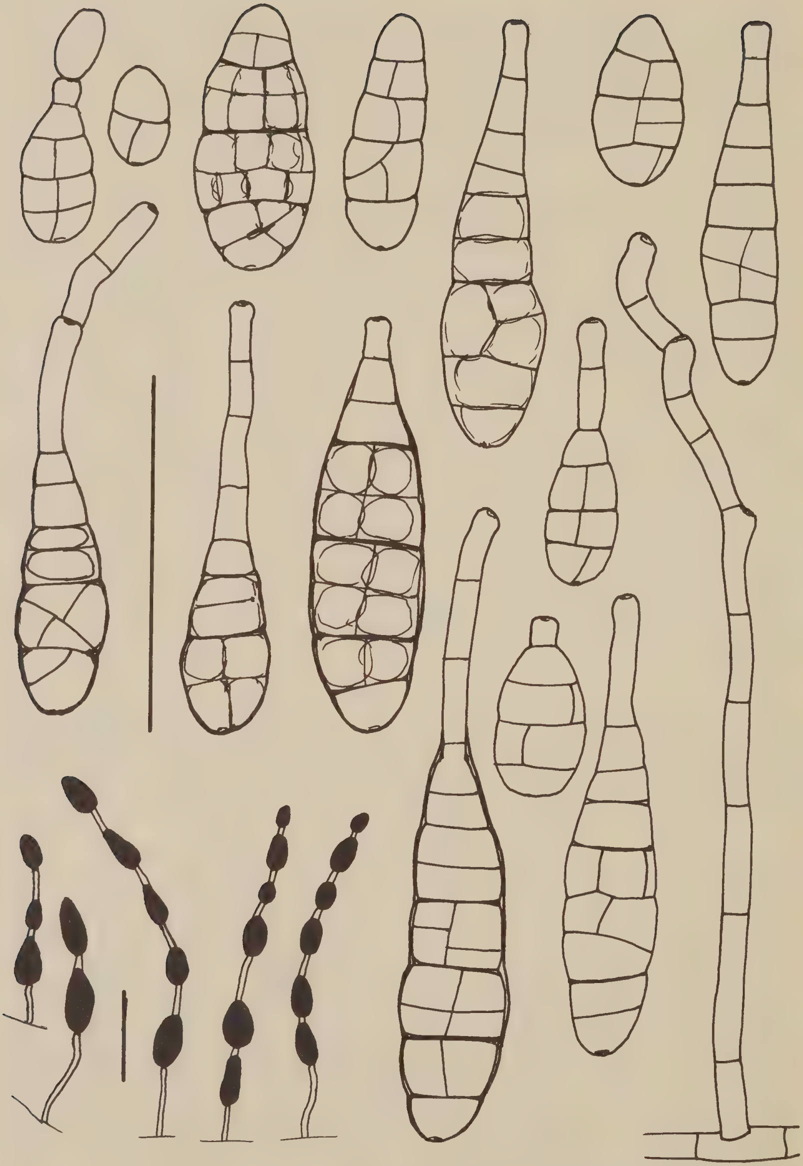

Fig. 63. *Alternaria arbusti*: characteristic conidia and primary and secondary conidiophores (line = 50 μm); characteristic sporulation pattern (line = 50 μm), conidia opaque, conidiophores clear. EGS 91-136.

primarily in short chains of robust conidia. However, conidia of *A. arbusti*, viewed at higher magnifications, show a more pronounced tendency to produce multicelled secondary conidiophores, are not appreciably ornamented, and have heavily pigmented walls and septa, all of which are characters foreign to typical *A. gaisen*.

Isolates of *A. arbusti* grow well and sporulate abundantly though not densely on the agars and under the conditions specified above. Surface and subsurface hyphae, viewed at 50X, are distinct in an openly radiating pattern. Primary conidiophores arising from these hyphae are abundant but not crowded. Very sparse aerial hyphae, when present, are conidiogenous. The 50X aspect is of uncrowded erect conidiophores, each bearing a solitary apical chain of 3-6 conidia (up to 8-10 as colony ages), or very frequently of geniculately extended conidiophores bearing a short chain of conidia at 2-4 different sites. This latter condition gives an impression of a clump of conidial chains; however, it is the primary conidiophore that proliferates, whereas the conidial chains themselves rarely branch at this early stage.

Primary conidiophores, viewed at higher magnifications, are simple and erect, often proliferating past 2-4 conidiogenous loci with or without strong geniculation. Conidiophores range in size up to about 130 x 4-5 μm and have medium olive-brown walls and darker septa. Fully developed conidia in short young chains are either ovoid (25-40 x 9-17 μm) or long ellipsoid (38-56 x 10-16 μm). Conidia are beakless, but each spore except the terminal one in a chain produces an apical secondary conidiophore of 1-5 cells (5-40 x 4-5 μm). Conidia are essentially smooth, medium olivaceous brown in color, and have 3-8 transverse septa and 1-2 longitudinal or oblique septa in 1-4 of the transverse segments. Many septa, particularly transverse ones, appear to be unusually thick and darker brown than the outer conidium walls. This character suggests embellisioid septa, but the appearance is deceptive in that the depth of septum color derives from the overlapping of pigmented internal cell walls rather than from a unified, comparatively wide band or hoop of pigmented wall typical of *Embellisia* septa. Conidium chains in young colonies usually are unbranched, although long secondary conidiophores may produce short chains at a few successive loci just as is done by primary conidiophores.

Isolates of *A. arbusti* were obtained from large rosy tan lesions of three different leaf specimens of *P. pyrifolia* (cultivar not known) collected by Dennis Margoson in a small farm orchard near Loomis, California, 2 August 1991: EGS 91.129, 91.132, and 91.136 (the latter isolate being used as source of holotype and isotype preparations). Another isolate (EGS 40-177) of the same species was isolated by Rodney G. Roberts before August 1988 from a cherry fruit (*Prunus* sp. cv. Rainier) in a sample from a commercial source in Washington State (specific orchard site not known).

Discussion and Conclusions

Comparison in culture of several hundreds of *Alternaria* isolates from Japanese pear substrates has permitted the selection of a morphological core group of strains to represent toxigenic *A. gaisen*. Although *A. gaisen* and several other taxa that produce host-specific toxins often are listed as morphologically indistinguishable from *A. alternata* (Kohmoto and Durkin 1989; Scheffer 1992), this study and an accompanying one (Simmons and Roberts 1993) present morphologic and toxigenicity evidence that *A. gaisen* is readily distinguishable from *A. alternata* in culture (and see Simmons 1992).

ACKNOWLEDGEMENTS

Dr. Mary E. Palm again has contributed time and expertise to the review of the prepublication manuscript. Her support of the entire pear black spot study is acknowledged in more detail in the accompanying paper (Simmons and Roberts 1993). Toxigenicity test data related here to taxonomic conclusions on *Alternaria gaisen* were supplied by Dr. Rodney G. Roberts, whose complete test results appear in the accompanying paper. All contributions of collections and isolates likewise are acknowledged in the cited paper.

It is a pleasure to remember Dr. Mary Watanabe who, when we both were associated with the U.S. Army Quartermaster General Laboratories, Philadelphia, about 40 years ago, introduced me to the intricacies of recognizing radicals and counting strokes in Japanese characters as a preliminary to use of Japanese-English dictionaries.

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ALTERNARIA THEMES AND VARIATIONS (73)

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ABSTRACT

A collection of several hundred *Alternaria* isolates from leaf, fruit, and twig lesions of Japanese pear has supported segregation and definition of at least six different patterns of sporulation among the small-spored, chain-forming taxa encountered. One of these patterns is typical of *A. gaisen* Nagano (syn. illegit. = *A. kikuchiana* Tanaka), which is pathogenic to some Japanese pear cultivars, causing "black spot disease." Some isolates that are toxigenic but not morphologic analogues of *A. gaisen* also were found. Six sporulation patterns are discussed from the viewpoint of classification problems with *A. alternata* (Fr.) Keissler and the numerous other morphologically distinct small-spored *Alternaria* taxa.

XII. MORPHOLOGY AND TOXIGENICITY OF ALTERNARIA ASSOCIATED WITH BLACK SPOT DISEASE OF JAPANESE PEAR

Introduction

A black spot disease very destructive to commercially valuable cultivars of *Pyrus pyrifolia* (N. L. Burm.) Nakai, particularly cv. Nijisseiki (20th Century), has been attributed consistently to named species of *Alternaria* since 1920 (Nagano). The degrees of uniqueness of the associated *Alternaria* species appear to have been largely a matter of increasing indifference, in that early papers emphasized aspects of pathology with only minor effort toward differential characterization of the *Alternaria* incitant, whereas later and current research papers focus on the physiology and intramolecular minutiae of several similar diseases of Japanese pear and of unrelated hosts, while lumping their several *Alternaria* incitants into a mycotaxonomically meaningless handful of "*Alternaria alternata* pathotypes," each reportedly producing a host-specific toxin (Kohmoto & Durkin 1989).

There has been lack of attention to the possibility that there may be some correlation between chemically defined complexes of host-specific toxins and morphologically definable, segregatable species of *Alternaria*. Thus, for example, when such morphologically dissimilar species as *Alternaria citri* Ellis & Pierce, *A. longipes* (Ellis & Everhart) Mason, and *A. brassicae* (Berkeley) Saccardo are noted as being "often classified as pathotypes of *A. alternata*" (Scheffer 1992), it becomes obvious that "Large quantities of critical and discriminating work in phytopathology and biochemistry are being lumped biologically under a fungus name that disguises the uniqueness of contributions of the several research groups" (Simmons 1992).

The nomenclature of the predominant toxigenic *Alternaria* associated with the black spot disease has been considered in a paper presented concurrently in this issue of Mycotaxon (Simmons 1993). The earliest legitimate name published for the species is *Alternaria gaisen* Nagano (1920). The name *A. kikuchiana* Tanaka (1933), an avowed substitute for the earlier name, is illegitimate and therefore cannot be maintained as the correct name of this fungus. Attempts to characterize the fungus have benefitted in recent years from the availability of toxigenic reference strains and fresh lesions on field specimens.

In July 1990 the Animal and Plant Health Inspection Service, U.S. Department of Agriculture, provided support and appropriate field connections in Japan that permitted Simmons to collect diseased leaves, fruits, and young sprouts of Japanese pear trees in experimental, commercial, and private orchards in Tottori, Nagano, and Fukushima prefectures. Roberts, supported by the U.S.D.A. Agricultural Research Service, participated throughout this *Alternaria* search in Honshu pear orchards and carried out the entire program of testing selected isolates for toxigenicity.

The trip yielded 500+ lesion collections, mostly from cv. Nijisseiki but also to a minor extent from cvs. Hosui, Kosui, and Shinsui. Most of these were circular black leaf spots a few millimeters to about 1 cm. in diameter; a few were black, cracked lesions in immature fruit; and a very few were of woody tissue adjacent to obviously diseased leaf petioles or fruit spurs. Several hundred single-conidium and single-chain *Alternaria* isolates (EGS) from these specimens yielded a set of about 200 stable strains. A further selection from these, along with isolates from other sources, constitute the working material supporting the taxonomic and related opinions given below. The same selection was used in the program of leaf inoculation tests (RGR), results of which are integrated here with taxonomic opinions (EGS).

Purposes of the Study

This foray among the kinds of *Alternaria* associated with lesions of Japanese pear has three major purposes:

1. To characterize *Alternaria* isolates shown experimentally to be capable of producing black spot lesions on leaves of Japanese pear cv. Nijisseiki; to segregate these isolates morphologically, if possible, from other groups of *Alternaria* isolates from similar habitats; and to determine the correct name for the black spot incitant.

2. To use this study of numerous small-spored but otherwise disparate *Alternaria* taxa as a vehicle for views on culturally observable diversity among such taxa. And especially to continue to correct popular but insufficiently informed pronouncements that *A. alternata* is a species so malleable, both morphologically and physiologically, that it defies specific definition, and so nearly ubiquitous that every small-spored *Alternaria* can, with scientific impunity, be treated as this single species.

3. To provide guidance in export-import plant control as to the nature of an *Alternaria* species/pear black spot relationship and its known distribution.

Materials and Methods

Alternaria isolates from diseased Japanese pear substrates (plus a very few from leaf spots of Chinese pear and apple trees near Japanese pear plantings) came from three kinds of sources:

-- directly from specimens collected, air dried, and shipped quickly from eastern Asia (Japan, Korea, Taiwan), or from commercial shipments of fruit from Japan intercepted at plant inspection facilities (U.S.A. and Australia);

-- directly from specimens collected, air dried, and shipped immediately from orchards and experimental plantings in the U.S.A. (California, Maryland, Michigan);

-- indirectly, as standard strains of an *Alternaria* used as a reference standard in toxicity studies in the laboratory of Dr. K. Kohmoto and Dr. H. Otani at the Faculty of Agriculture, Tottori University, and as culturally representative strains at the Tottori Fruit Tree, Vegetable and Flower Experiment Station.

All but eight of the isolates selected for detailed microscopic and toxigenicity study were made by Simmons from fresh sporulation that developed from excised lesion tissue held for one to a few days under damp-chamber conditions.

A selection of 349 isolates considered potentially useful (factors of cultural stability, research standard, geographic source) was screened in comparative culture on a weak potato/carrot agar (PCA), hay decoction agar (Hay), and V-8 juice agar (V-8). (See **Media**, p. 136-137.) The strains were sorted into groups on the basis of similarities in colony development and sporulation patterns visible at 50X magnification.

A final pool of 132 strains was selected to represent not only the several 50X segregate groups but also some non-black spot sources (e.g., post-harvest rot of Japanese pear, Texas air, California tomato, straw mulch in a Tottori pear orchard, and *Alternaria alternata* from non-rosaceous habitats). All of these were studied at 195X and 780X for morpho-taxonomic purposes. A set of 134 cultures (132 + 2 serial reisolates of the Tottori standard toxic strain) was shipped to Roberts for blind tests on leaves of very susceptible Japanese pear cv. Nijisseiki. Roberts was given no information about the source or characteristics of any of these isolates except for an indication that at least one represented the toxicity standard strain *Tottori 15A*. (See **Table I**, pp. 138-140.)

The ability of the selected isolates to produce diagnostic necrotic lesions on juvenile 'Nijisseiki' leaves was evaluated as follows by Roberts. Upon receipt from Simmons, all isolates were promptly lyophilized with minimal (usually one) transfer. No microscopic observations were made of any culture. Lyophilized isolates were revived on half-strength V8 juice agar and grown for 7-14 days at 18C under a 16/8 hr cool-white fluorescent-UV light/dark cycle. Conidial suspensions were prepared at 10^5 conidia/ml in sterile deionized water as determined by hemacytometer, placed on ice, and used within one hr. Six- to 10-day-old leaves were harvested from a 'Nijisseiki' orchard in Cashmere, Washington, and surface disinfested by immersion in 5,250 μg ml^{-1} NaOCl for one min, then rinsed thoroughly in running, sterile deionized water. Leaves were placed abaxial side up on paper toweling in a moist chamber. In order to minimize leaf-to-leaf variability, one 10 μl drop of each conidial suspension was placed on each of five leaves per isolate. Each leaf received six drops representing six different isolates, three on either side of the mid-vein. Inoculated leaves were held at ca. 24C for 48 hr, then the presence of dark brown to black necrotic lesions was recorded. All isolates were tested in three separate trials. Neither leaf-to-leaf nor trial-to-trial variability in lesion development was observed. In all three trials, either all or none of the five inoculation loci developed distinctive, well defined lesions.

Other conventions used in this discussion include: herbarium and culture collection abbreviations are from Holmgren et al. (1990), given here in boldface type; references to records of material studied are in record volume-page format, e.g., EGS 37-132; routine culture conditions include PCA, Hay, and V-8 agars in plastic Y-plates at ca. 22C under a 10/14hr, cool-white fluorescent light/dark cycle; microscopic details are recorded from observations made at 195X and 780X.

Sporulation Patterns at 50X Magnification

Not all *Alternaria* with small/medium size conidia borne in chains are *A. alternata* (Fr.) Keissler, despite the mislabelling of hundreds of *Alternaria* specimens and cultures in the herbaria, working collections, and culture collections of the world. Proof of such a statement is less easily provided from field material than it is from stable isolates, for the progress and pattern of sporulation in culture can easily be observed at 50X or less, whereas a sporulation pattern on a field collection, even if distinctive, almost invariably is disrupted in examination. The examiners of field material find themselves viewing and measuring disjunct conidia whose relationships to others in the sample are, for three-dimensional visualization purposes, practically unknowable; they then are left with little choice but to record conidium size ranges and to make comparisons and (mis)identifications on this limited and ineffective basis.

Before describing and discussing the different kinds of sporulation patterns exhibited among the several hundred *Alternaria* isolates handled in this study, it is essential to point out the pitfall of relying heavily on size-range data in *Alternaria* identifications and to discredit the importance of such data in first-line characterization of the numerous chain-forming *Alternaria* species whose mature spore populations are predominantly of conidia of moderate size, i.e., ca. 25-60 μm in length.

To emphasize this caution, it is convenient to quote from a recently published discussion of *Alternaria* taxonomy (Simmons 1992):

> "Probably the greatest impediment to attempts to differentiate similar species of *Alternaria*, particularly those of the small-spored groups, is the universal practice of studying a slide preparation of conidiophores and conidia at high magnifications (300-500X) without also determining at moderate magnifications (50-60X) the sporulation pattern of conidia produced by a single conidiophore. The three-dimensional sporulation pattern and the relationships of neighboring conidia are effectively mutilated in any slide preparation, whereas the intact arrangements of conidial chains and branches in stable isolates often exhibit striking heritable differences.
>
> "Conidium size ranges, obligatory in an *Alternaria* species description, lose their primary significance when it can be demonstrated that the same size ranges are present in remarkably different sporulation groups. For example, under specific conditions of growth, conidia of *Alternaria alternata* are produced in a loose three-dimensional tuft of branching chains; but it is no great trick to find another taxon with conidia of the same size range which, however, are produced in a single linear chain that does not branch under the same conditions."

Almost all of the hundreds of isolates studied in this search for the identity of the Japanese pear black spot *Alternaria* produce conidia of moderate size range, i.e., up to ca. 50-60 μm long. Typical *A. alternata* falls in this size group, as do *A. citri* Ellis & Pierce, *A. infectoria* Simmons, *A. longipes* (Ell. & Everh.) Mason, and several other species.

However, cultures of the pear isolates (7-10d, PCA, examined by transmitted light at 50X) can be sorted into several groups on the basis of different sporulation patterns. The eye accustomed to examining significant numbers of *Alternaria* cultures can differentiate perhaps a dozen such patterns, stable and recognizable in cultures produced under the specified conditions. But anyone with experience or interest in examining plate cultures of dark-spored molds can easily discern at least five or six distinct sporulation patterns at this moderate magnification. These patterns and some of their variants are discussed below, along with comments on additional segregates defined by conidium characters visible at 195X and 780X.

The major groups observed in this study, each represented by large numbers of isolates (except for Group 4), are (Fig. 64, here below, and 65-70):

1. Short to moderate-length chains of 5-10 conidia; chain branching none or minor. Chains usually appear somewhat lean in comparison with those of Group 2.

2. Short to moderate-length, unbranched chains (max. ca. 10 conidia). Many conidia in chains appear robust, i.e., broader (even to the eye at 50X) than the less remarkable conidia of Group 1.

3. Arborescent, compact or open clumps of branching chains of short to moderate length. The conspicuous "trunk" of such a tree-like formation is the dark, short to sometimes very long primary conidiophore that rises directly from the substrate or from a hyphal branch and sporulates primarily near its apex.

4. Bushy clumps of well-branched chains of conidia. The primary conidiophores are short or inconspicuous in comparison with those of arborescent Group 3.

5. Moderate-length to long chains of 10-15(-20) conidia; branching minor or none. Conidia appear somewhat lean at 50X and usually lack the "robust" look of Group 2.

6. Loose clumps of branching chains, the broader spore-body elements connected by abrupt, rather coarse, often elongate secondary conidiophores.

7.8.9. Various patterns of branching clumps and long, poorly or abundantly branching chains; recognizable, but with characters overlapping those of other groups. Found only in USA-MD and USA-CA isolates; none toxigenic. Not characterized or treated further here.

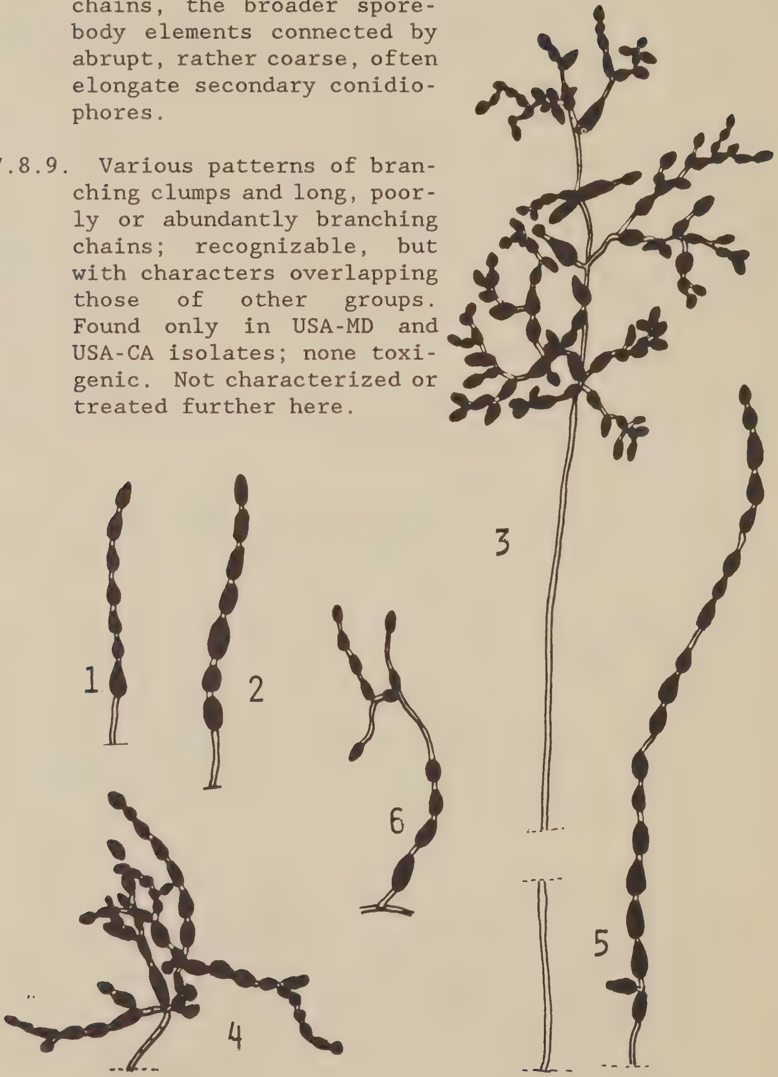

Fig. 64. Patterns of *Alternaria* sporulation discussed in adjoining text. Sporulation groups numbered as in text descriptions. All patterns drawn to same scale.

Discussion of Group Segregates (PCA, 50X)

Group 1 (Fig. 65) Strains that produce chains of short to moderate length (5-10, usually without side branches) during the first week of growth on PCA constitute the most abundant sporulation pattern found among isolates from Japan sources. In initial screening, this group was intended to comprise all isolates in which unbranched chain elongation appeared to be comparatively slow, often only 5-6 conidia per chain, and only rarely more than 10 in the first week of colony development. The relative sizes of the largest conidia visible at 50X were not taken into account until it was noted that Group 2, reserved for standard toxic strain *Tottori 15A* and a few nearly identical isolates of varying stability, contained strains with chains of short to moderate length but whose conidia always had a comparatively robust appearance. After segregation of "robust" strains into Group 2, along with *Tottori 15A*, Group 1 became an aggregate of isolates that produce chains of comparatively lean appearance in the early days of sporulation.

All 14 test strains assigned to this Group 1 came from Japan (13) or from Taiwan. Three of these test positive for toxicity to Nijisseiki leaves.

Group 2 (Fig. 66) This group of strains is based primarily on the sporulation characters of *Tottori 15A*, viz., short to moderate-length, usually unbranched chains of relatively robust conidia. *Tottori 15A* (EGS 37-132, received in 1984; test strain 002) exhibits some evidence of aberration in plate culture (fragile, non-sporulating hyphae among otherwise heavily sporulating mycelium); it sporulates better on PCA and V-8 than on Hay. It is used in the Tottori University laboratory of Dr. K. Kohmoto (our source of the isolate) as a toxigenic reference strain.

Serial 1-chain reisolates from *Tottori 15A* have yielded strains with slightly more abundant sporulation and reduced non-sporulating hyphae (test strains 003 and 044). Some of the other more recent Group 2 isolates sporulate very well and do not have significant amounts of non-sporulating hyphae during early growth stages.

Of 22 strains assigned definitely or possibly to Group 2 on the basis of sporulation similarity to *Tottori 15A*, 19 have tested positive for toxicity to Nijisseiki leaves. All of the 19 morphologic and toxigenic analogues of *Tottori 15A*

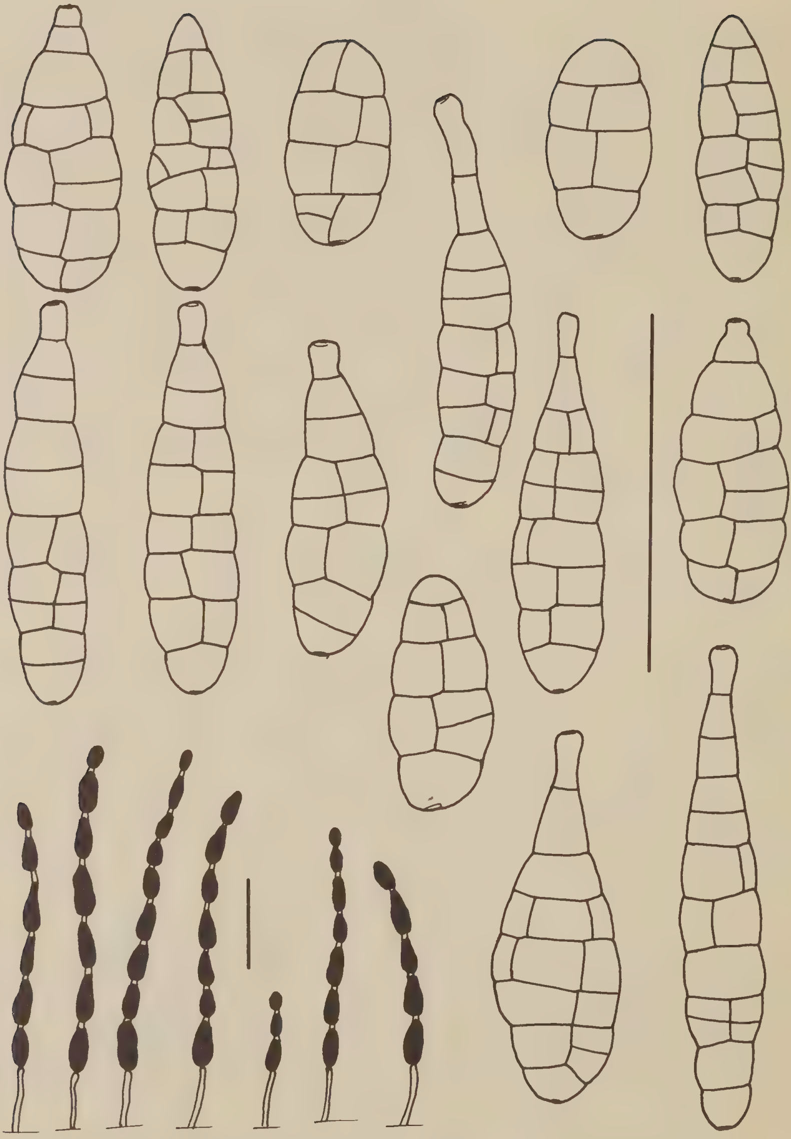

Fig. 65. Group 1: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm).

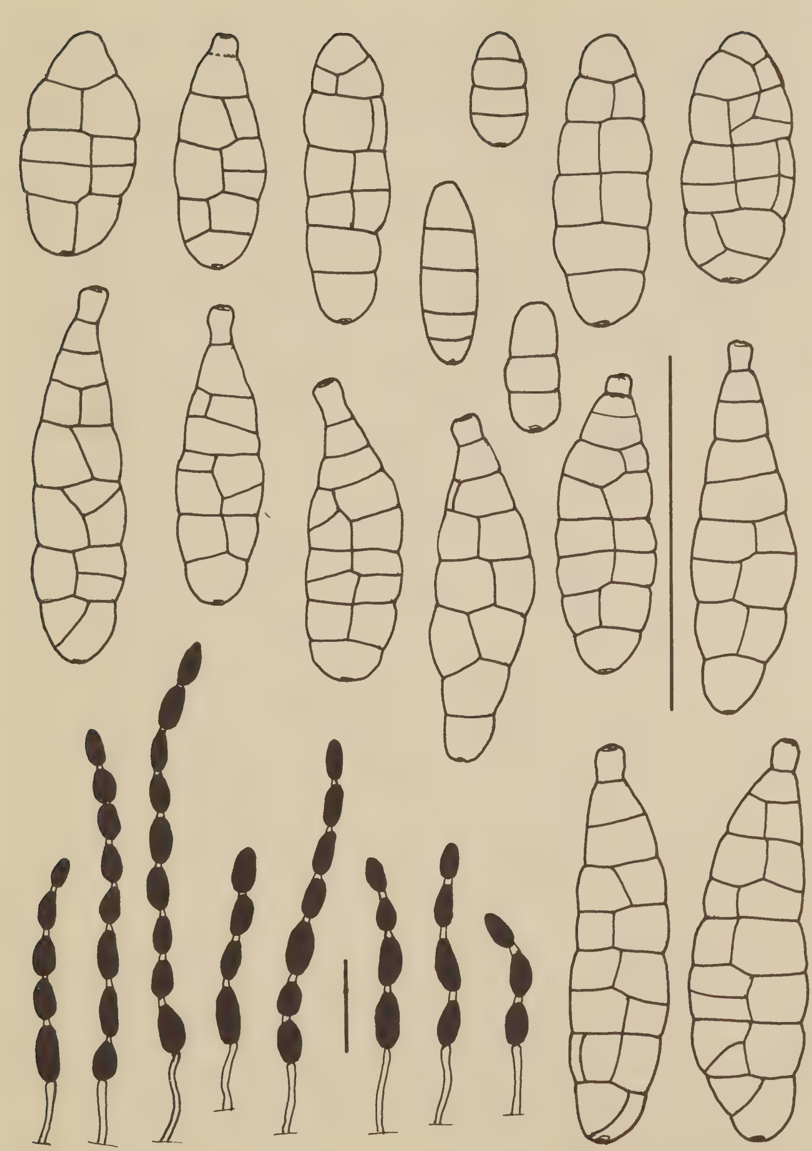

Fig. 66. Group 2: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm). *Alternaria gaisen* group representative.

were from Japan, Korea, or Taiwan, or from exported Japanese pears intercepted at Seattle, Washington, U.S.A., and Rydalmere, Australia. These 19 toxigenic isolates represent *Alternaria gaisen* Nagano, an expanded description of which is presented in Simmons (1993).

The other three isolates with a robust-conidium character similar to that of *Tottori 15A* were isolated from spreading, rosy-tan lesions commonly seen on Asian pear leaves collected in California; these lesions do not at all resemble black spot lesions seen in Japan, Korea, and Taiwan. These three isolates and an additional one from a Washington State cherry cv. Rainier, immediately recognizable at 195X and morphologically distinguishable from *Tottori 15A* analogues, are negative in tests against Nijisseiki leaves. The three are representative of a new species *A. arbusti* Simmons, described as novel in the companion paper (Simmons 1993).

Group 3 (Fig. 67) Isolates have more or less compact clumps of branching conidial chains borne aloft on dark primary conidiophores. During early days of colony development such conidiophores usually originate singly near the agar surface, often in large numbers. Sporulation may occur on relatively short conidiophores (50-70 μm long), but the diagnostic picture at 50X is of primary conidiophores that tend not to sporulate or branch before the conidiophore has reached an appreciable length (often 100-150 μm or more), after which a series of geniculations and short conidiogenous branches gives rise to a head of branching chains of conidia.

This sporulation type was very abundant among the initial isolates, especially in those from Japan but also in those from California, Maryland, and Taiwan.

A fairly large selection of 28 isolates of this type was incorporated in the final test series in order to accomodate the considerable variation in primary conidiophore length and size and in density of the sporulation clumps as seen at 50X. No isolate of the 28 test strains representing this arborescent sporulation pattern induced a positive reaction in toxicity tests against Nijisseiki leaves. (A single positive test isolate (098) that originally might have been considered to have the Group 3 sporulation pattern now is seen to have aberrant, possibly hyphally parasitized vegetative mycelium. Because of this, there can be no confidence in choice of sporulation group for isolate 098, which is indicated as "?" in Table I.)

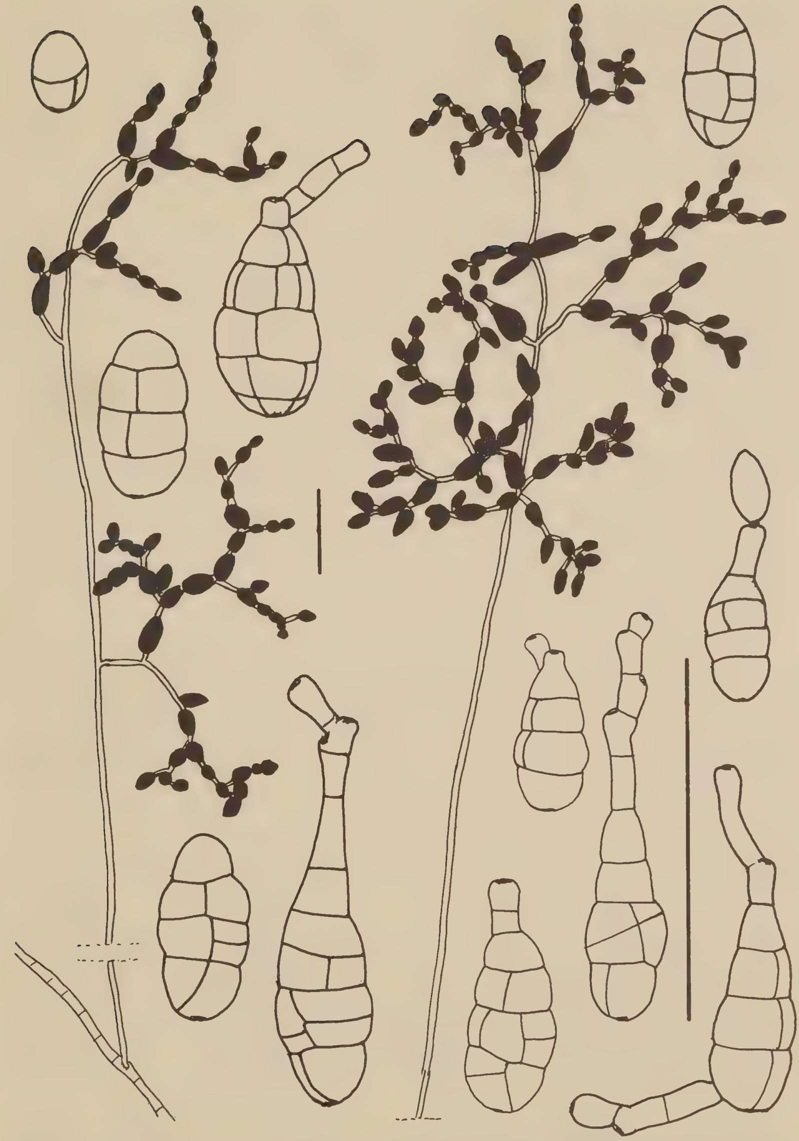

Fig. 67. Group 3: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm).

Group 4 (Fig. 68) This group is based specifically on the characters of isolates selected a few years ago as morphologically representative of the Simmons concept of typical *Alternaria alternata* in culture. (EGS 34-016, 34-039, 35-056, and 35-193; deposited in culture collections **ATCC**, Rockville, MD, U.S.A., **CBS**, Baarn, The Netherlands, **DAOM**, Ottawa, Canada, **IFO**, Osaka, Japan, and **IMI**, Kew, U.K.)

This group, distinct even at 50X from any of the preceding groups, encompasses isolates with low bushy (not arborescent) clumps of well-branched chains of relatively small conidia. Early sporulation exhibits patterns from solitary branching chains to branching clumps, but the progression is toward somewhat dense, branching clumps, which are typical. Isolates of *A. alternata* that have been selected for uniformity and stability of growth and sporulation form a dense turf of black clumps in an expanding series of concentric rings. The clumps are produced so abundantly on PCA and V-8 agars that it sometimes is difficult to see the limits between adjacent clumps at 50X. However, clumps produced on Hay agar tend to be less crowded and are quite discrete at the edge of a colony as it approaches the periphery of a culture dish.

Examples of typical *A. alternata*, or even of strains with an *A. alternata* group resemblance, were rare among the several hundred initial isolates examined. Two isolates from USA-CA plantings of Japanese pear fit this group pattern. Two isolates from pear leaf and fruit lesions (Tottori) and three isolates from apple leaf lesions (Nagano) also fit this *A. alternata* group pattern. None of these isolates from pear and apple lesions and none of the morphologically typical reference strains of *A. alternata* from miscellaneous non-pear sources were toxigenic in tests against Nijisseiki leaves.

Group 5 (Fig. 69) Isolates in young cultures produce moderately long to long chains of 10-15(-20) conidia; branching of chains usually is minor (1-2 conidia) or lacking. Chains have a somewhat lean appearance at 50X, similar to that of Group 1 chains and in contrast to the compact, robust look of Group 2 chains.

This sporulation type is observed frequently among isolates from Japan, Korea, California, and Michigan. Of 32 isolates selected to represent a variety of colony appearance and geographic distribution, 27 were negative in tests against Nijisseiki leaves. The other five, all from Japan,

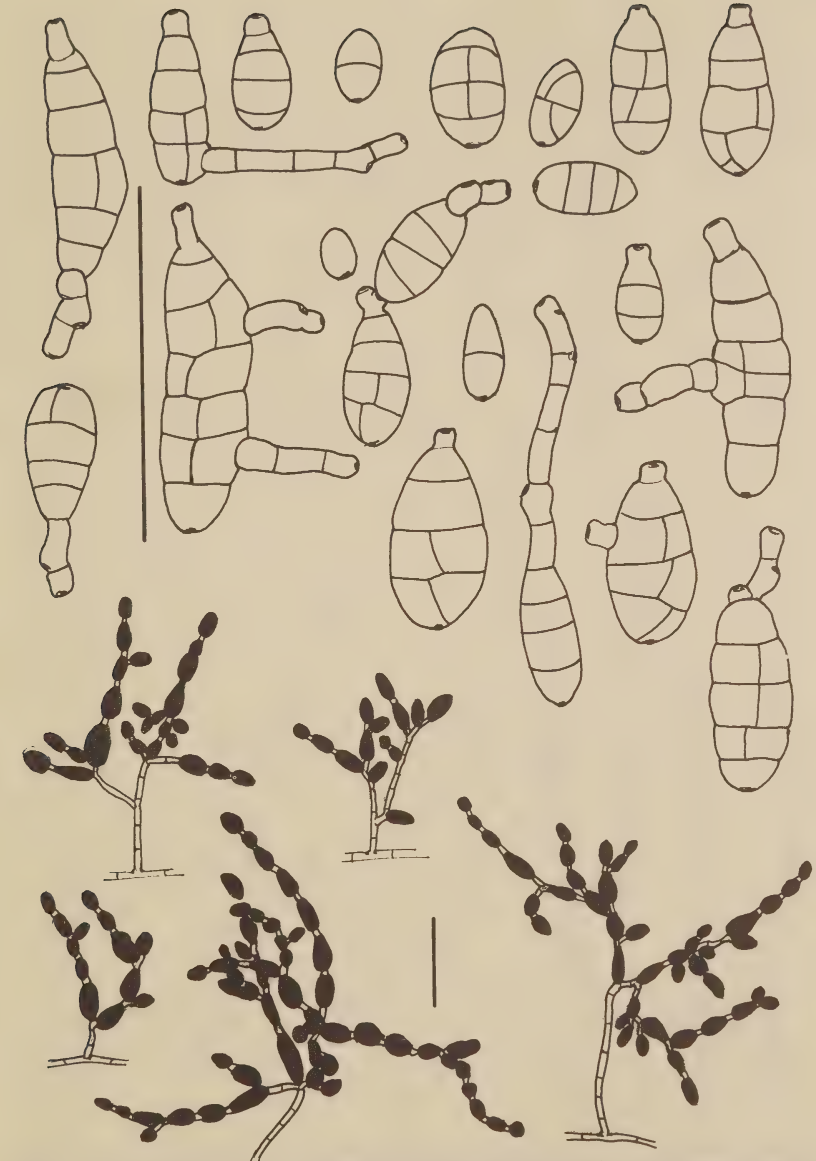

Fig. 68. Group 4: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm). *Alternaria alternata* group representative.

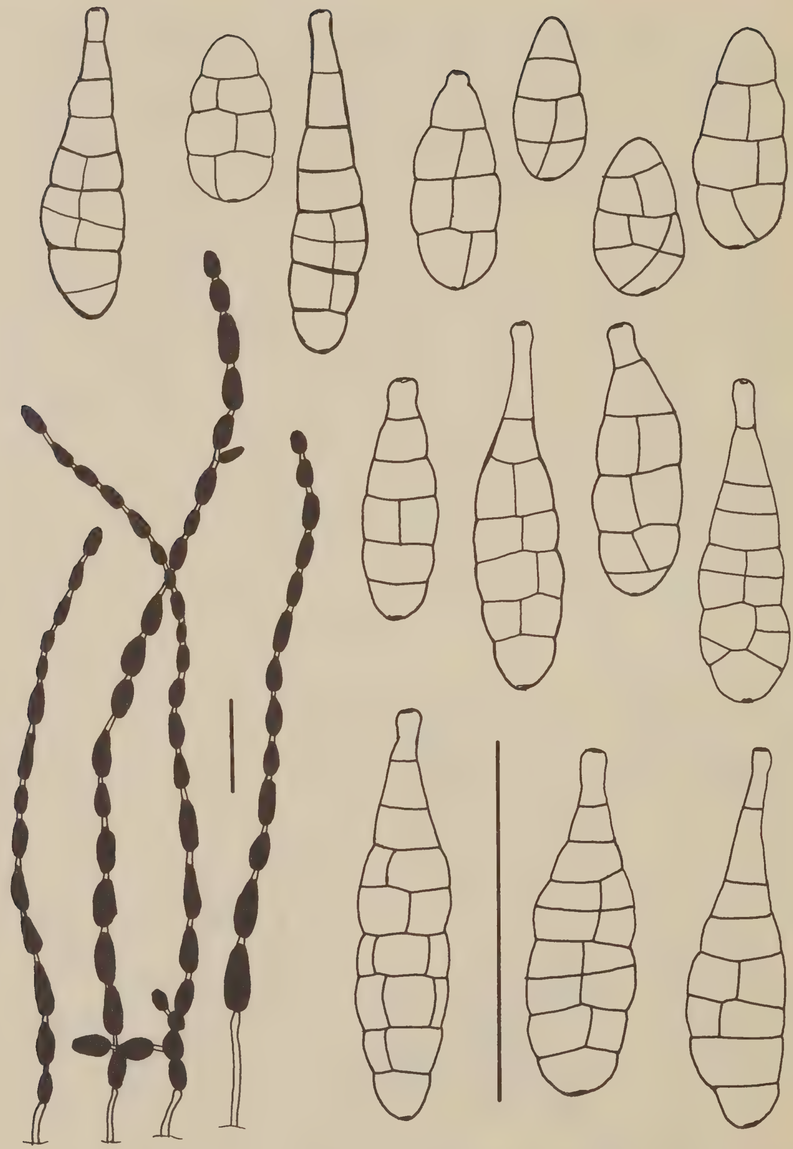

Fig. 69. Group 5: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm).

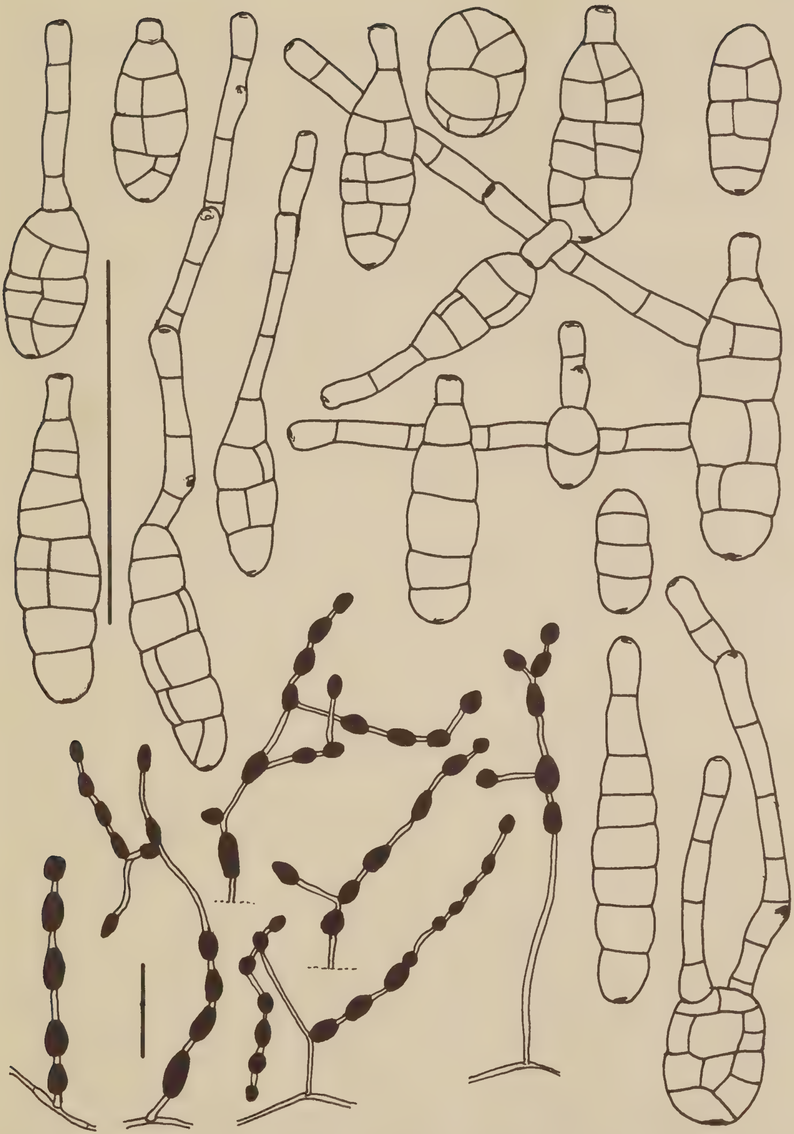

Fig. 70. Group 6: characteristic sporulation pattern (PCA 5d.; line = 50 μm; conidium bodies opaque, conidiophores clear); fully developed individual conidia with secondary conidiophores that define sporulation pattern (line = 50 μm). *Alternaria infectoria* group representative.

were positive. The five positive strains are discussed below in the context of the taxonomy of the black spot *Alternaria*.

Group 6 (Fig. 70) Isolates in young cultures produce loose clumps of branching chains whose conidial elements are separated by strong, readily distinguishable pseudorostrate connectives. (Several isolates not readily assignable to this or previous groups are found, when examined at higher magnifications, to have similar pseudorostrate chain elongation without appearing conspicuously so at 50X.)

Isolates of this type are abundant among strains from Maryland and California, rare among Taiwan isolates, and questionable or lacking among those from Japan. None of seven in the test set proved toxic to cv. Nijisseiki leaves.

Groups 7,8,9 Additional sporulation groupings used in the initial sorting to accommodate some patterns of sporulation that are fairly abundant among U.S.A. isolates but were not recognized in those from Asian sources. Since most of these have 50X characters overlapping other groups to some degree (especially arborescent Group 3), they are not considered further in the present taxonomic context. No isolate of the 17 chosen to represent these overlapping groups was positive in toxicity tests against cv. Nijisseiki leaves.

Discussion of the Grouping Exercise and Subsequent Toxicity Testing

An initial observation is inescapable: the only *Alternaria* strains in the test set that are able to produce black spot reactions in Japanese pear cv. Nijisseiki leaves equivalent to those produced by toxigenic strain *Tottori 15A* were isolated from Japanese pear material that originated in Japan, Korea, or Taiwan. (See **Table I**.)

Speaking strictly from within the defined limits of this exercise, all test isolates from U.S.A. material were negative in toxicity challenges to cv. Nijisseiki leaves.

A caveat: no one, especially not we, would claim that a comprehensive search has been made in the U.S.A. for *Alternaria* that can produce black spot disease of Japanese pear. The numerous isolates from Maryland and Michigan used in this study were made from material collected by Simmons in a private orchard, a nursery, and some experimental plantings. At these sites he looked for and collected only lesions that had some similarity to the kinds of leaf and fruit lesions given to him by specialists in Japan, Korea, and Taiwan as typical of the disease. Isolates from California sources were made by him from material collected by colleagues searching in privately owned orchards. No specimen received from California bore lesions of the kind typically found in Japan and neighboring regions, although the searchers had been given information about what to look for.

Alternaria species constitute an overwhelming majority of the dematiaceous outgrowths encountered during these isolation attempts from Japanese pear lesions. (Significant numbers of *Cladosporium* and *Epicoccum*, in particular, also occur.) Despite the abundance of *Alternaria*, the percentage of toxigenic isolates in the overall *Alternaria* component of this habitat is low.

A very rough estimate of occurrence of toxigenicity among the approximately 400 isolates studied by us from East Asia would fall well below 10%. A closer calculation is not possible, as testing was carried out with only 71 strains from East Asia sources, cultures having been selected on a purely morphological basis to represent the different patterns of sporulation observed.

Similarly, a major survey of airborne *Alternaria* in a Japanese orchard of susceptible pear cv. Nijisseiki has shown that only 2.1% of 515 isolates produced pear-specific toxins in culture and that only one of 575 *Alternaria* isolates from an orchard of resistant cv. Kosui was toxigenic (Nishimura et al. 1982).

The results of the attempt to define sporulation groupings in cultures compared at 50X are taxonomically somewhat assuring, in view of the poverty of published information on the systematics of small-spored *Alternaria*. This opinion derives from the most striking portion of the grouping exercise, which centered on selection of 22 strains considered to be morphologically similar at 50X to toxigenic *Tottori 15A* (Group 2). Nineteen of the 22 proved toxigenic in controlled tests against cv. Nijisseiki leaves. (The three non-toxigenic isolates of this group are markedly dissimilar when examined at higher magnification.)

Eight additional toxigenic strains, when young, fit better into other sporulation groups (1 and 5). This observation does not destroy the predictability of a core group of morphological characters being associated with toxicity to susceptible cultivars of Japanese pear. These characters are ascribed to a single *Alternaria* species, namely *A. gaisen*, related to black spot disease of Japanese pear. The species and some morphologically variant but also toxic isolates are presented below in a taxonomic discussion of this material.

Alternaria gaisen Nagano as the Incitant of Black Spot Disease of Japanese Pear

Efforts discussed in the early pages of this study were directed toward segregating isolates with similar sporulation patterns from a pool of several hundred strains derived from Japanese pear substrates. Group assignments were made on the basis of examination at 50X magnification of stable colonies developed for about seven days on PCA.

Six groups were defined, illustrated, and discussed. It is anticipated that some of the group boundary choices may be considered overly subjective. The only reply can be that certainly there is overlapping of character expression in the chronological development of any population of microscopic fungi but that, under specific growth conditions, stable isolates of small-spored *Alternaria* produce conidiophore and conidium sporulation patterns that are describable and groupable and, to a high degree, diagnostic when combined with characters of conidia viewed at higher magnifications.

In this study no isolate in sporulation morphology groups 3, 4, and 6 was toxigenic in experimental inoculations. These three groups contain all sporulation types that exhibit abundant geniculate extensions of conidiophores (each geniculation the site of origin of a conidium and potentially of a chain) and abundant branching of conidium chains (due to production of secondary conidiophores laterally from conidia). Group 4, with low bushy sporulation clumps, is represented by typical *A. alternata*. Group 6, with a moderately to highly skeleton-like system of secondary conidiophores, contains *A. infectoria* Simmons and *A. conjuncta* Simmons (Simmons 1986), anamorphs of *Lewia* species. Group 3, with a moderately to very tall arborescent pattern of sporulation, has not yet been assigned a representative named taxon.

All but three isolates of Group 2 (comparatively short chains of robust conidia) are microscopically similar to reference strain *Tottori 15A* and, like it, are toxigenic.

The *Tottori 15A* analogues are of a single species, *A. gaisen*; their characters were used by Simmons (1993) in discussing the taxon in its most restricted sense. The three exceptional isolates that differ microscopically from *A. gaisen* have been described as *A. arbusti* E. Simmons (1993).

Most isolates of Group 1 (comparatively short chains of conidia less robust than those of *A. gaisen*) are non-toxigenic. However, three of the 14 representatives of this group repeatedly proved toxigenic in tests and, therefore, require reconsideration as to group placement and, certainly, close comparison with typical *A. gaisen* at higher magnifications.

Most isolates of Group 5 (comparatively long, rarely branched chains of conidia) also are non-toxigenic. However, 5 of the 29 representatives of this group repeatedly proved toxigenic in tests and also require further comparison with the typical *A. gaisen* group.

Group 1 and Group 5 Toxigenic Isolates Morphologically Variant from Representative *A. gaisen* (Group 2)

Most of the pear isolates that have proved to be toxigenic have sporulation characters similar to those of strain 057 (representative *A. gaisen*) and of 044 (reisolated *Tottori 15A*), in that chains of conidia are short and usually unbranched, conidia are mostly broadly ovoid or ellipsoid, giving a subjective impression of robustness at 50X, and conidia preponderantly have a well-defined median septum and either an apical 1-celled secondary conidiophore or none.

Group 1 As noted earlier, three (011, 035, 039) of the 14 lean or less robust strains of short-chained Group 1 have proved as toxic to test leaves as did representative *A. gaisen* (Group 2) strains. The 50X segregation of these three isolates from Group 2 robust toxic strains becomes questionable when conidium samples are examined at higher magnifications.

Conidium bodies of isolate 011 are basically those of representative *A. gaisen*. However, secondary conidiophores in the chain frequently are elongate and multiseptate (instead of the usual short 1-cell condition) and thus give chains a leaner aspect than is seen when most secondary conidiophores are short and the chains are compact.

Short chains of 035 and 039 and the conidia in them are recognizably *A. gaisen*. However, longer chains (up to about 10 conidia) frequently comprise not only robust, short-beaked conidia but also conidia with long, pale, somewhat attenuate secondary conidiophores that terminate in a slightly swollen conidiogenous cell. The spore body of such conidia is essentially that of representative *A. gaisen*. These conidia constitute a very small percentage of the spore population, but they are significant in a classification sense in that they give a pronounced appearance of leanness and elongation to chains viewed at 50X.

All three of these isolates are *A. gaisen*, though morphologically variant from the basic description derived from Group 2 representative isolates 057 and 044 (Simmons 1993). These three and similar isolates (including some among long-chained Group 5 isolates) always will present difficulties in identification if the unusually elongate, tapering secondary conidiophores are given more weight than their accessory or secondary nature merits.

Group 5 As noted earlier, five of the 32 long-chained isolates of Group 5 also have proved toxigenic as consistently as have representative *A. gaisen* strains of Group 2. Sporulation pattern and conidium morphology are variant enough among these toxigenic five that three of them can readily be interpreted as long chain versions of *A. gaisen* whereas the other two cannot.

Isolate 055, 061 and 062 can be interpreted as *A. gaisen* despite having long chains of conidia and a minor tendency to produce short lateral chains of 2-3 conidia. Typical robust conidia are abundant within populations that tend otherwise toward narrowly ellipsoid elements.

Isolate 052 is morphologically anomalous among toxigenic strains in that, although some robust unbranched chains are produced, most sporulation follows a pattern of initially large to small conidia in variously branching chains, a pattern that is unknown among the numerous other toxigenic isolates.

Isolate 092 also is anomalous in that nearly all of its conidia are smaller than those of representative *A. gaisen*. Only a few of its largest conidia produced on V-8 agar (not on PCA) approach the size and proportions of representative strains.

Group 1 and Group 5 Nontoxigenic Isolates

Some toxigenic isolates morphologically variant from representative *A. gaisen* (Group 2) key initially into 50X groups 1 and 5 because of an abundance of elongate secondary conidiophores. Some of these variant strains, however, can be interpreted as *A. gaisen* on the basis of spore samples studied at high magnifications, as discussed above.

The other 38 representative isolates of Group 1 (short, lean chains) and Group 5 (long chains), all nontoxigenic, are readily distinguishable at high magnifications not only from representative *A. gaisen* but also from toxigenic isolates of their own groups 1 and 5.

All 11 nontoxigenic Group 1 isolates produce conidia that, for the most part, are smaller or narrower than those of toxigenic strains. Although a very small minority of the largest, broadest conidia of each nontoxigenic strain cannot be distinguished readily from the great majority of conidia in toxigenic isolates, the overall pattern of conidium morphology in nontoxigenic Group 1 isolates is of narrow-ellipsoid (ca. 32-43 x 11-13 μm) and comparatively small ovoid (ca. 19-29 x 10-14 μm) spores quite unlike the relatively large, robust (30-45 x 13-15 μm) conidia that predominate and are considered diagnostic in *A. gaisen*.

Of the 27 nontoxigenic Group 5 isolates, all but one can be differentiated readily from toxigenic isolates by morphologic criteria. The exceptional one (093, Nagano), with numerous large, robust conidia as well as a high percentage of small conidia, is somewhat similar to toxigenic but morphologically anomalous Group 5 isolates 052 and 092 (Tottori).

Another of the nontoxigenic Group 5 isolates (046, Nagano) is quite different from all other strains encountered in this study. Its predominantly elongate, pale, often narrow-beaked conidia in long chains have permitted its being treated as a distinct species, *A. rhadina* E. Simmons (1993).

All other nontoxigenic Group 5 isolates produce large numbers of spores distinctly smaller (ca. 19-27 x 10-13 μm) than the common size range of *A. gaisen* conidia (30-45 x 13-15 μm). Each of the many strains of this category usually produces some, even numerous conidia of sizes that reach the *A. gaisen* range. But such large conidia never constitute a significant percentage within the overwhelmingly small-spored populations. For example:

-- isolate 056 (Tottori) has an uncommon upper size range of 35-40 x 11-13 μm in a population of otherwise distinctly smaller conidia.

-- isolates 094 and 095 (Tottori) have an uncommon upper range of 29-43 x 11-14 μm, with the longer conidia relatively narrow (ca. 43 x 11 μm) and the shorter ones of this range (ca. 29 x 14 μm) relatively broad.

-- isolates 023, 063 and 065 (Michigan) are much like 094 and 095, with an upper range of 27-43 x 10-13 μm, abundant long narrow conidia (ca. 43 x 10 μm), and otherwise predominantly small conidia (ca. 22 x 10 μm).

-- isolate 108 and many others from California have an upper range of 27-42 x 10-13 μm for a low percentage of conidia, with the great bulk of others distinctly smaller and in some cases with a type of septation (almost embellisioid) not seen in *A. gaisen*.

The preponderance of relatively small conidia in the long chains of all members of this last group of isolates prevents them from being confused with representative *A. gaisen* or, for that matter, with any toxigenic isolate examined in this study.

Discussion and Conclusions

This paper, ostensibly on the black spot disease of Japanese pear and the identity of the incitant *Alternaria* species, evolved readily into an examination and discussion of distinctive patterns of sporulation observable among small-spored species of *Alternaria*, including *A. gaisen*.

Selecting representative *A. gaisen* (Simmons 1993) proved not to be a major problem after a significant number of stable isolates had been assembled. However, the initial program of isolating as many *Alternaria* strains as possible from pear black spot lesions led to an accumulation of several hundreds of small-spored isolates. These exhibited a great diversity of sporulation patterns and thus afforded the luxury of exploring some species-group concepts on the basis of a large number of stable, superficially similar cultures available at one time. The opportunity was too good to miss, in that published information on criteria for segregation of taxa among small-spored *Alternaria* is practically nonexistent.

The conclusions from this examination are fewer than might be wished for, but more than we have had before now:

Small-spored, chain-forming species of *Alternaria* sporulate in discernible, distinctive patterns. The appearance of each pattern, usually visible at 50X magnification in plate culture, is defined by the primary conidiophore (length, branching, linear proliferation), the conidia (size, shape, color density), the chains (number of conidia, absence or presence of branching), and the interconidial secondary conidiophores (length, linear proliferation, pattern of branching if present).

Cultures about one week old on PCA usually present a population of individual sporulation structures that have reached stages of development representative for the isolate before crowding, conidium germination, and aerial overgrowth become obscurant.

Six relatively common and basic patterns have been described here from among the hundreds of Japanese pear isolates studied. One of these patterns (Group 2) is typical of most of the toxigenic *Alternaria gaisen* isolates studied. A few other toxigenic isolates are found in two other sporulation groups (1 and 5). Some of these, viewed at higher magnifications, have conidia that can be interpreted as variants within *A. gaisen*. A few other toxigenic strains are not morphologically acceptable as *A. gaisen* as defined here.

The original purposes of this study, stated near the beginning of the paper, have been achieved to a reasonable but not complete extent.

1. Most of the *Alternaria* test isolates that are experimentally toxic to Japanese pear leaves have the same 50X sporulation pattern and the same microscopic conidium and chain morphology. This group has been selected to represent *Alternaria gaisen* Nagano. Members of this group, segregated on a morphological basis, are predictably toxigenic among the scores of isolates tested.

However, toxigenic isolates have been encountered that are morphologically incongruent with *A. gaisen*. Their toxigenicity is not predictable within the context of the morphological comparisons made here. Since these toxigenic, non-*A. gaisen* isolates were selected for the toxigenicity test set as morphological representatives of several other strains, it seems likely that toxigenicity may occur in a larger number of the initial hundreds of isolates than the tests themselves would indicate.

2. A few common, basic sporulation patterns have been defined to represent the diversity observed. In addition, a suggestion has been made that anyone who maintains that "*Alternaria alternata*" is a biologically justifiable receptacle for all small-spored, chain-producing *Alternaria* might better take a close look at several stable, controlled cultures, their sporulation patterns, and their microscopic characters. The resulting contrasts surely will give pause to some of the obviously derivative misinformation on the morphologic and physiologic malleability of *A. alternata* and other small-spored taxa of the genus. Typical *A. alternata* was extremely rare among isolates examined; no isolate of *A. alternata*, from Japanese pear or any other source used for comparison, was toxigenic to cv. Nijisseiki leaves under test conditions.

3. The uniqueness of an *A. gaisen*/black spot of Japanese pear relationship is questionable at present. Given a pear isolate that produces relatively short chains of robust conidia with the microscopic characteristics attributed to *A. gaisen* (Simmons 1993), it is highly predictable that it will be toxigenic. However, there are comparatively long-chain isolates from similar habitats that also are toxigenic; this latter relationship is not predictable at present, suggesting that production of the pear black spot toxin may not be species restricted within *Alternaria*.

4. It is pertinent to mention that, in our collecting, *Alternaria* seldom was found in a sporulating condition in nature on black spot lesions (except within cracks of diseased fruit). Moreover, a very high proportion of Japanese pear leaf lesions of any sort yielded *Alternaria* growth under laboratory isolation conditions, but only a small percentage of retrievals proved to be toxigenic. The situation is similar to that found, for example, in the brown spot disease of tobacco, from lesions of which the emergence of *A. longipes* (Ell. & Ev.) Mason, the toxigenic incitant, often is tardy or sparse and, thus, either accounts for a minor percentage of isolates or is overlooked entirely.

5. An earlier observation is repeated here, that the only toxigenic *Alternaria* strains in our morphology-based test set (representing several hundred isolates from East Asia and U.S.A. orchards) were isolated from Japanese pear material that originated in Japan, Korea, and Taiwan.

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MEDIA

The following three simple media are sufficient and recommended for practically all routine comparison work with *Alternaria* isolates.

PCA: 20g white potato, 20g carrot, 20g agar; autoclave diced vegetables in small amount of water until tissue is well softened; force slurry through fine sieve; add distilled water to make 1 liter; add agar; sterilize (pH not adjusted).

Hay: 50g decomposing grasses (mature, late season or overwintered, naturally decaying leaf and culm debris; not rotting green material), 1000ml water; autoclave at 15 lb pressure for 30 minutes; filter through lightweight cotton gauze (e.g., cheesecloth). Add water to filtrate to make 1000ml, 2g K_2HPO_4, 20g agar; autoclave 10 min; adjust to pH6.0-6.5; sterilize.

V-8: 175ml V8 vegetable juice (6 fl. oz.), 3g $CaCO_3$, 20g agar, water to make 1 liter; sterilize (unadjusted pH ca. 6.4). [V8 juice (Campbell Soup Co.) has proved to be a useful medium in fungus culture work. Since this commercial preparation is unlikely to be readily available on a worldwide basis, a reasonable substitute based on tomato juice probably can be devised. Additional ingredients listed on the commercial label are juices (presumably in minute quantities) of carrot, celery, beet, parsley, lettuce, watercress, and spinach, plus salt, ascorbic acid, and citric acid.]

TABLE I: Ref. nos., toxigenicity, 50X groupings, sources

Key: * 50X characters overlap other groups; ** fruit intercept in Australia; *** fruit intercept in USA; MLV = Malvaceae, LEG = Leguminosae, SOL = Solanaceae, GRM = Gramineae, MUS = Musaceae

Test Code	EGS Record	Toxi-genic.	50X Grp.	Source	Region	Substr.
001	35.0560	- - -	4	(Repr. *A. alternata*)		MLV
002	37.1321	+ + +	2	Japan (*15A*)	Tottori	pear-Ja
003	37.1322	+ + +	2	Japan	Tottori	pear-Ja
004	37.1330	+ + +	2	Japan	Tottori	pear-Ja
005	38.1830	+ + +	2	Korea		pear-Ja?
006	39.0020	- - -	5	Korea		pear-Ja
007	39.0030	+ + +	2	Korea		pear-Ja
008	39.1590	+ + +	2	Japan	Tottori	pear-Ja
009	39.1600	+ + +	2	Japan	Tottori	pear-Ja
010	39.1610	- - -	4	Japan	Tottori	pear-Ja
011	38.1480	+ + +	1	Taiwan		pear-Ja
012	38.1522	- - -	3	Taiwan		pear-Ja
013	38.1531	- - -	3	Taiwan		pear-Ja
014	38.1551	- - -	3	Taiwan		pear-Ja
015	38.1561	+ + +	2	Taiwan		pear-Ja
016	38.1510	+ + +	2	Taiwan		pear-Ja
017	90.0031	+ + +	2	Japan	Tottori	pear-Ja
018	90.0522	- - -	1	Japan	Tottori	pear-Ja
019	90.0523	- - -	3	Japan	Tottori	pear-Ja
020	90.1641	- - -	3	Japan	Fukushima	pear-Ja
021	90.1642	- - -	3	Japan	Fukushima	pear-Ja
022	90.1072	- - -	3	Japan	Nagano	pear-Ja
023	91.0030	- - -	5	USA	MI	pear-Ja
024	91.0412	- - -	5	USA	MI	pear-Ja
025	91.0590	- - -	3	USA	MD	pear-Ja
026	91.0600	- - -	6	USA	MD	pear-Ja
027	91.0630	- - -	6	USA	MD	pear-Ja
028	91.0690	- - -	*7	USA	MD	pear-Ch
029	34.0160	- - -	4	(Repr. *A. alternata*)		LEG
030	40.0300	- - -	6	USA	CA	pear-Ja
031	40.0330	- - -	4	USA	CA	pear-Ja
032	90.0041	+ + +	2	Japan	Tottori	pear-Ja
033	90.0101	- - -	1	Japan	Tottori	pear-Ja
034	90.0131	- - -	1	Japan	Tottori	pear-Ja
035	90.0161	+ + +	1	Japan	Tottori	pear-Ja
036	90.0391	+ + +	2	Japan	Tottori	pear-Ja
037	90.0451	- - -	1	Japan	Tottori	pear-Ja
038	90.0522	- - -	1	Japan	Tottori	pear-Ja

039	90.0671	+	+	+	1	Japan	Tottori	pear-Ja
040	90.0981	-	-	-	1	Japan	Nagano	pear-Ja
041	90.0991	-	-	-	1	Japan	Nagano	pear-Ja
042	90.1011	-	-	-	1	Japan	Nagano	pear-Ja
043	90.1061	-	-	-	1	Japan	Nagano	pear-Ja
044	37.1323	+	+	+	2	Japan	Tottori	pear-Ja
045	39.1290	-	-	-	3	USA	CA	SOL
046	90.1482	-	-	-	5	Japan	Nagano	pear-Ja
047	90.1621	-	-	-	3	Japan	Fukushima	pear-Ja
048	90.1441	-	-	-	3	Japan	Nagano	pear-Ja
049	90.1601	-	-	-	3	Japan	Fukushima	pear-Ja
050	90.1690	-	-	-	3	Japan	Fukushima	pear-Ja
051	90.1700	-	-	-	3	Japan	Fukushima	pear-Ja
052	90.0351	+	+	+	5	Japan	Tottori	pear-Ja
053	90.0621	-	-	-	5	Japan	Tottori	pear-Ja
054	90.0960	-	-	-	5	Japan	Nagano	pear-Ja
055	90.0972	+	+	+	5	Japan	Nagano	pear-Ja
056	90.0511	-	-	-	5	Japan	Tottori	pear-Ja
057	90.0512	+	+	+	2	Japan	Tottori	pear-Ja
058	90.0640	-	-	-	4	Japan	Tottori	pear-Ja
059	90.0690	-	-	-	3	Japan	Tottori	pear-Ja
060	90.0720	-	-	-	3	Japan	Tottori	pear-Ja
061	90.0820	+	+	+	5	Japan	Tottori	pear-Ja
062	90.0880	+	+	+	5	Japan	Tottori	pear-Ja
063	91.0090	-	-	-	5	USA	MI	pear-Ja
064	91.0080	-	-	-	5	USA	MI	pear-Ja
065	91.0210	-	-	-	5	USA	MI	pear-Ja
066	91.0422	-	-	-	5	USA	MI	pear-Ja
067	91.0050	-	-	-	5	USA	MI	pear-Ja
068	91.0361	-	-	-	5	USA	MI	pear-Ja
069	91.0392	-	-	-	3	USA	MI	pear-Ja
070	91.0140	-	-	-	4	USA	MI	pear-Ja
071	91.0200	-	-	-	6	USA	MI	pear-Ja
072	91.0430	-	-	-	6	USA	MD	pear-Ja
073	91.0440	-	-	-	6	USA	MD	pear-Ja
074	91.0470	-	-	-	6	USA	MD	pear-Ja
075	91.0450	-	-	-	*8	USA	MD	pear-Ja
076	91.0560	-	-	-	*8	USA	MD	pear-Ja
077	91.0510	-	-	-	*8	USA	MD	pear-Ja
078	91.0520	-	-	-	*8	USA	MD	pear-Ja
079	91.0480	-	-	-	*8	USA	MD	pear-Ja
080	91.0500	-	-	-	*9	USA	MD	pear-Ja
081	91.0460	-	-	-	*9	USA	MD	pear-Ja
082	91.0490	-	-	-	*9	USA	MD	pear-Ja
083	91.0550	-	-	-	*9	USA	MD	pear-Ja
084	91.0540	-	-	-	*9	USA	MD	pear-Ja
085	91.0530	-	-	-	*9	USA	MD	pear-Ja
086	90.0081	-	-	-	3	Japan	Tottori	pear-Ja

087	90.0071	-	-	-	1	Japan	Tottori	pear-Ja
088	90.1682	-	-	-	5	Japan	Fukushima	pear-Ja
089	90.0851	-	-	-	3	Japan	Tottori	pear-Ja
090	90.1071	-	-	-	3	Japan	Nagano	pear-Ja
091	90.0112	-	-	-	3	Japan	Tottori	pear-Ja
092	90.0780	+	+	+	5	Japan	Tottori	pear-Ja
093	90.1022	-	-	-	5	Japan	Nagano	pear-Ja
094	90.0750	-	-	-	5	Japan	Tottori	GRM
095	90.0760	-	-	-	5	Japan	Tottori	GRM
096	90.1290	+	+	+	2	Japan	***	pear-Ja
097	90.1310	+	+	+	2	Japan	***	pear-Ja
098	90.1160	+	+	+	?	Japan	***	pear-Ja
099	90.1220	+	+	+	2	Japan	***	pear-Ja
100	38.0660	-	-	-	4	Australia		?
101	39.1680	+	+	+	2	Japan	**	pear-Ja
102	30.1340	-	-	-	5	USA	TX	air
103	38.1740	-	-	-	4	USA	CA	air
104	35.1930	-	-	-	4	(Repr. *A. alternata*)		MUS
105	34.0390	-	-	-	4	(Repr. *A. alternata*)		SOL
106	91.0700	-	-	-	*7	USA	CA	pear-Ja
107	91.0720	-	-	-	*7	USA	CA	pear-Ja
108	91.0740	-	-	-	5	USA	CA	pear-Ja
109	91.0770	-	-	-	*7	USA	CA	pear-Ja
110	91.0790	-	-	-	3	USA	CA	pear-Ja
111	91.0800	-	-	-	*7	USA	CA	pear-Ja
112	91.0830	-	-	-	5	USA	CA	pear-Ja
113	91.0840	-	-	-	*7	USA	CA	pear-Ja
114	91.0890	-	-	-	3	USA	CA	pear-Ja
115	91.0930	-	-	-	5	USA	CA	pear-Ja
116	91.0960	-	-	-	3	USA	CA	pear-Ja
117	91.0970	-	-	-	5	USA	CA	pear-Ja
118	91.0980	-	-	-	3	USA	CA	pear-Ja
119	91.1040	-	-	-	5	USA	CA	pear-Ja
120	91.1050	-	-	-	5	USA	CA	pear-Ja
121	91.1080	-	-	-	3	USA	CA	pear-Ja
122	91.1150	-	-	-	3	USA	CA	pear-Ja
123	91.1220	-	-	-	3	USA	CA	pear-Ja
124	91.1230	-	-	-	5	USA	CA	pear-Ja
125	91.1280	-	-	-	5	USA	CA	pear-Ja
126	91.1290	-	-	-	2	USA	CA	pear-Ja
127	91.1320	-	-	-	2	USA	CA	pear-Ja
128	91.1360	-	-	-	2	USA	CA	pear-Ja
129	91.1370	-	-	-	5	USA	CA	pear-Ja
130	90.0530	-	-	-	4	Japan	Nagano	apple
131	90.0550	-	-	-	4	Japan	Nagano	apple
132	90.0580	-	-	-	1	Japan	Fukushima	apple
133	90.0941	-	-	-	5	Japan	Nagano	apple
134	90.0942	-	-	-	4	Japan	Nagano	apple

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THREE NEW SPECIES OF TALAROMYCES FROM NEPAL

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ABSTRACT

Three new species of *Talaromyces* C. R. Benjamin, *T. convolutus*, *T. emodensis* and *T. tardifaciens*, are described and illustrated. They were isolated from paddy and roadside soils in Kathmandu Valley, Nepal. All are, as species belonging to the series *Lutei* typified by *T. luteus*, characterized by restricted growth on common media, bright yellow ascomata and small subglobose or broadly ellipsoidal spinulose ascospores.

As a part of studies on the soil mycoflora in Kathmandu Valley in Nepal (Udagawa and Sugiyama, 1982; Udagawa and Horie, 1982; Udagawa, 1990; Takada and Udagawa, 1993; Yaguchi et al., 1993a, b), the three species of *Talaromyces* (Trichocomaceae, Eurotiales) dealt with in this paper were isolated from paddy and roadside soils. They proved to be distinctly different from all species of *Talaromyces* previously described (Stolk and Samson, 1972; Samson and Abdel-Fattah, 1978; Pitt, 1979; von Arx, 1987; Takada and Udagawa, 1988; Frisvad et al., 1990; Tsuen et al., 1992; Yaguchi et al., 1992, 1993a, b; Takada and Udagawa, 1993), and are herein described as new species.

Talaromyces convolutus Udagawa, sp. nov. Figs. 1, 2

Coloniae in agaro Czapekii valde restrictae. Coloniae in agaro "Czapek-yeast extract (CYA)" restrictae, floccosae, sulcatae, ex mycelio basali coacto compacto constantes, flavae, ascomatibus abundantibus formantes; conidiogenesis nulla; reversum ferrugineum vel persicinum. Coloniae in agaro maltoso (MEA) effusae, floccosae, planae,

ex mycelio basali coacto tenuiter constantes, flavae, ascomatibus et conidiis tarde formantes; reversum pallide aurantiacum vel croceum. Coloniae in agaro farinae zeae paulo effusae, planae, tenues, ex mycelio vegetativo submerso et ascomatibus numerosis constantes, flavae; conidiogenesis sparsa et inconspicua; reversum incoloratum.

Ascomata non-ostiolata, discreta vel confluentia, prompte maturescentia, flava, globosa vel subglobosa, 150-400 µm diam, mollia, mycelio laxo flavo incrustato sinuato obtecta; paries ex hyphis ramosis septatis levibus stramineis intricatis compositus. Asci breviter catenulati, 8-spori, subglobosi vel ovoidei, 6.5-9 x 5.5-7 µm, evanescentes. Ascosporae hyalinae, late ellipsoideae, 2.5-3.5 x 2-2.5 µm, interdum subglobosae, 2-2.5 µm diam, spinulosae. Status anamorphus: *Penicillium convolutum*.

Ubiquinonum majus: Q-10(H_2).

Holotypus SUM 3018, colonia exiccata in cultura ex solo, Kathmandu, in Nepalia, 30.ix.1986, a S. Udagawa isolata et ea collectione fungorum, Musei et Instituti Historiae Naturalis Chiba (CBM) conservata.

Etymology: from Latin, *convolutus*=convolute, referring to the coiled pattern of ascomatal initials.

Anamorphosis: *Penicillium convolutum* Udagawa, anam. nov.

Conidiophora ex hyphis aeriis oriunda; stipites hyalini, 25-100 x 2-3 µm, leves vel prope basin parum asperati, septati. Penicilli plerumque biverticillati. Metulae (2-)4-6 verticillatae, plerumque adpressae, (8-)10-14 x 2-2.5 µm. Phialides 3-4 verticillatae, acerosae, 10-14 x 1.5-2 µm. Conidia hyalina, plerumque subglobosa, 1.5-2.5 µm diam, levia, in catenis implicatis connexa. Status teleomorphus: *Talaromyces convolutus*.

Holotypus SUM 3018, loc. cit.

Colonies on Czapek agar growing extremely slowly, attaining a diam of 2 mm within 7 days at 25°C. Colonies on CYA growing restrictedly, attaining a diam of 4-7 mm within 7 days and up to 20 mm within 14 days at 25°C, floccose, sulcate, consisting of a compact basal felt, Yellow (M. 2A6, after Kornerup and Wanscher, 1978) or Pure Yellow (Rayner, 1970); ascomata abundantly produced within 14 days; conidiogenesis lacking; exudate abundant, clear; odor musty; reverse Pastel Red (M. 9A4) to Reddish Brown (M. 8D5) or Peach to Rust (Rayner). Colonies on MEA growing rather rapidly, attaining a diam of 12-16 mm within 7 days and up to 42 mm within 14 days at 25°C, floccose, plane, consisting of a thin basal felt with Pastel Yellow (M. 2A4) or Pure Yellow (Rayner) aerial

hyphae; ascomata and conidia not appearing within 7 days and tardily produced; exudate abundant, clear; reverse Light Orange (M. 5A4) or Saffron (Rayner). Colonies on cornmeal agar growing rather rapidly, attaining a diam of 14-15 mm within 7 days and up to 42 mm within 14 days at 25°C, plane, thin, with vegetative mycelium submerged, producing numerous ascomata in a thin layer, Yellow (M. 2A6) or Pure Yellow (Rayner); conidiogenesis sparse, not sufficiently produced to influence the colony appearance; reverse uncolored.

Ascomata non-ostiolate, discrete or confluent, maturing within 14 days, pure yellow, globose to subglobose, 150-400 µm in diam, soft, loosely covered by yellow, encrusted, sinuous mycelium; ascomatal wall composed of a loose network of branched, septate, smooth-walled, straw-colored, interwoven hyphae measuring 1-2 µm in diam. Ascomatal initials developing as short branches of hyphae with tightly coiled tips. Asci in short chains, 8-spored, subglobose to ovoidal, 6.5-9 x 5.5-7 µm, evanescent. Ascospores hyaline, small, broadly ellipsoidal, 2.5-3.5 x 2-2.5 µm, sometimes subglobose, 2-2.5 µm in diam, spinulose with small spines.

Conidiophores arising from aerial hyphae; stipes hyaline, 25-100 x 2-3 µm, smooth-walled or slightly roughened at the basal part, septate. Penicilli biverticillate, sometimes monoverticillate or terverticillate. Metulae in verticils of (2-)4-6, mostly appressed, (8-)10-14 x 2-2.5 µm, smooth-walled. Phialides in verticils of 3-4, lanceolate, 10-14 x 1.5-2 µm, smooth-walled. Conidia hyaline, mostly subglobose, 1.5-2.5 µm in diam, sometimes ovoidal, smooth-walled, in disordered chains.

Major ubiquinone: Q-10(H_2).

At 37°C, growth is restricted.

Specimen examined: SUM 3018 (holotype), in dried culture isolated from soil, Ring Road, Kathmandu, Nepal, Sept. 30, 1986. The holotype has been deposited with the Natural History Museum and Institute, Chiba, Japan.

On account of its growth-rate of less than 30 mm diam on MEA in 7 days and its bright yellow mycelium, *T. convolutus* is clearly related to species in the series *Lutei* of the sect. *Talaromyces*, as defined by Pitt (1979). However, it differs from the other members of the series by slower growth on CYA and MEA, tightly coiled ascomatal initials, the small spinulose ellipsoidal ascospores, and the small subglobose conidia. The ascomatal initials of *Talaromyces helicus* (Raper et Fennell) C. R. Benjamin (Raper and Fennell, 1948; Stolk and Samson, 1972; Pitt,

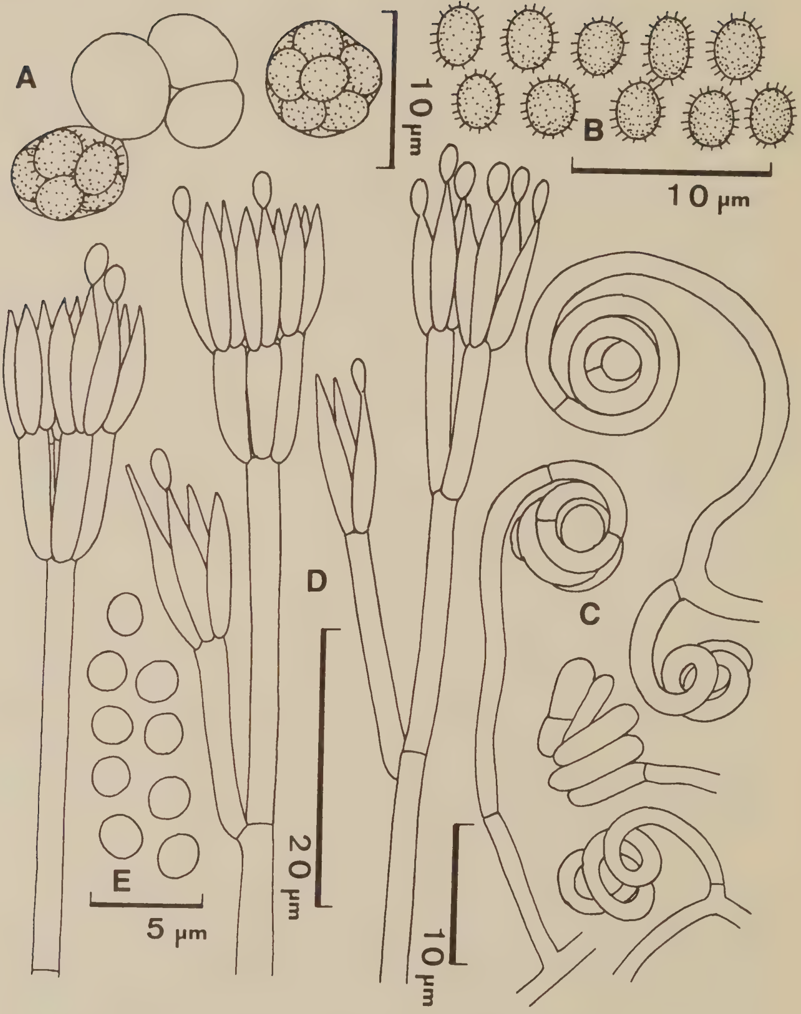
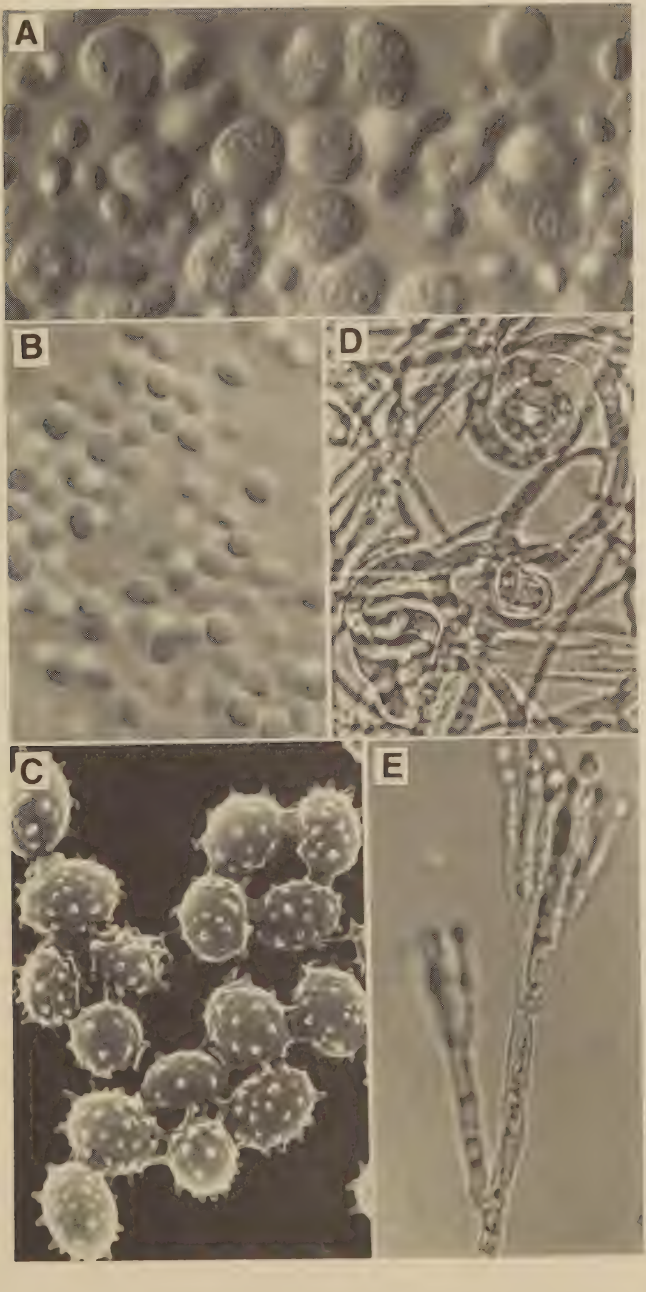

A
10 µm
B
10 µm
D
C
E
5 µm
20 µm
10 µm

Fig. 1. *Talaromyces convolutus*, SUM 3018. A. Asci. B. Ascospores. C. Ascomatal initials. D. Penicilli. E. Conidia.

Fig. 2. *Talaromyces convolutus*, SUM 3018. A. Asci, x 1250. B. Ascospores, x 1250. C. Ascospores (SEM), x 4000. D. Ascomatal initials, x 1250. E. Penicillus, x 1250.


A
B
D
C
E

1979)in the series *Flavi* are somewhat reminiscent of those of this species, but differ in producing fine antheridia encircling large cylindrical ascogonial cells.

Talaromyces emodensis Udagawa, sp. nov. Figs. 3, 4

Coloniae in agaro Czapekii valde restrictae, floccosae, irregulariter convolutae, ex mycelio basali coacto tenuiter constantes, umbonatae, albae vel flavae vel sulphureae, ascomatibus tarde formantes; conidiogenesis nulla; reversum croceum vel badium. Coloniae in CYA restrictae, floccosae, plus minusve radiatim sulcatae, tenues, ascomatibus flavis abundantibus formantes; conidiogenesis inconspicua vel saepe nulla; reversum croceum vel badium. Coloniae in MEA restrictae, floccosae, convolutae, ex mycelio basali coacto tenuiter constantes, ascomatibus dense formantes, flavae vel sulphureae; conidiogenesis nulla; reversum fulvum vel ochraceum. Coloniae in agaro farinae zeae paulo restrictae, planae, tenues, ex mycelio vegetativo submerso constantes, albae vel flavo-albae vel stramineae, ascomatibus tarde formantes; conidiogenesis inconspicua vel nulla; reversum incoloratum.

Ascomata non-ostiolata, discreta vel confluentia, tarde maturescentia, sulphurea, globosa vel subglobosa, plerumque 120-350 µm diam, mollia, mycelio laxo radiato flavo incrustato ramoso septato obtecta; paries ex hyphis laxis cremeis incrustatis dense intricatis compositus. Asci breviter catenulati, 8-spori, globosi vel late ovoidei, 8-11 x 7.5-9 µm, evanescentes. Ascosporae hyalinae vel dilute flavae, globosae vel subglobosae, 2.5-3 µm diam, interdum late ovoideae, 3-3.5 x 2.5-3(-3.5) µm, plus minusve incrassatae, spinulosae. Status anamorphus: *Penicillium emodense*.

Ubiquinonum majus: Q-10(H_2).

Holotypus SUM 3025, colonia exiccata in cultura ex solo agresti, Kathmandu, in Nepalia, 4.ix.1986, a S. Udagawa et ea in collectione fungorum, Musei et Instituti Historiae Naturalis Chiba (CBM) conservata.

Etymology: from Greek, *emodensis*=The Himalayas, pertaining to the Himalayas, the type locality.

Anamorphosis: *Penicillium emodense* Udagawa, anam. nov.

Conidiophora ex hyphis aeriis oriunda; stipites breves, 18-60 x 2-2.5 µm, hyalini, leves, septati. Penicilli monoverticillati sed saepe irregulares. Rami interdum producentes, 15-25 µm longi. Phialides 2-3 verticillatae, acerosae, 10-17.5 x 2-3 µm, saepe solitariae, ad 60 µm

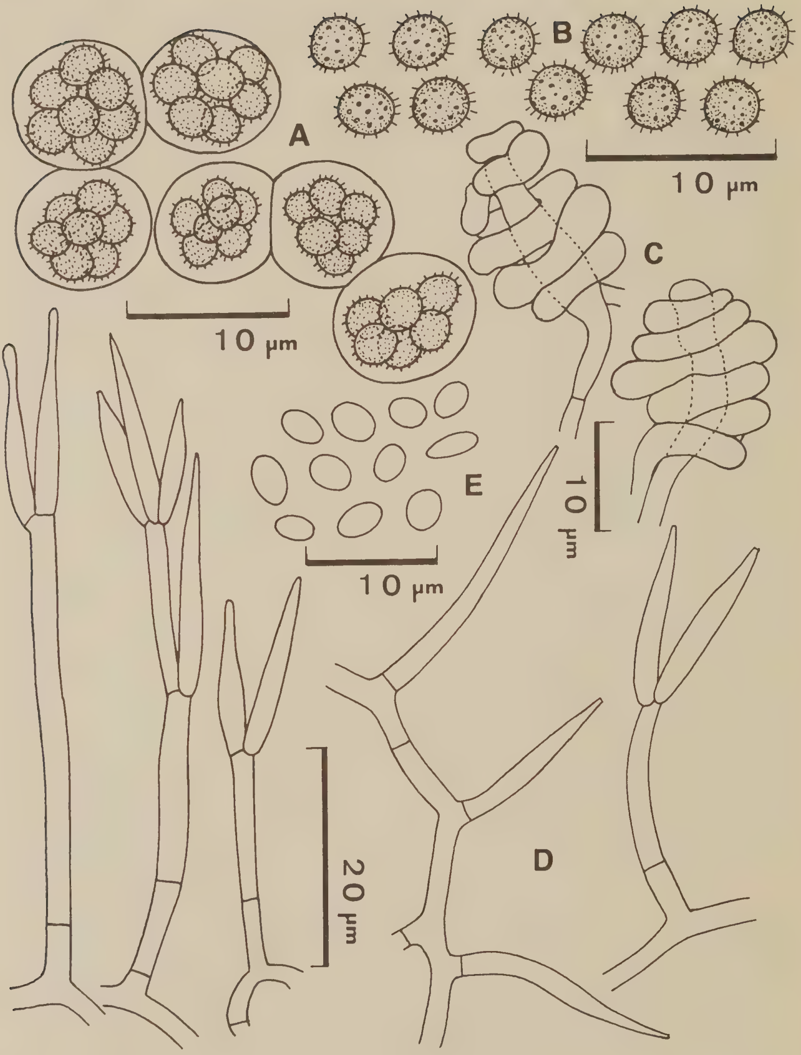
longae. Conidia hyalina, ovoidea vel ellpsoidea, 3-4 x 1.5-3 µm, levia, in catenis brevibus implicatis connexa. Status teleomorphus: *Talaromyces emodensis*.

Holotypus SUM 3025, loc. cit.

Colonies on Czapek agar growing very restrictedly, attaining a diam of 7-10 mm within 7 days at 25°C, floccose, irregularly convolute, consisting of a thin basal felt, raised in central area, Pastel Yellow (M. 1A4) or Sulphur Yellow (Rayner) in color from the scattered ascomata which are embedded in the felt; conidiogenesis lacking; reverse Greyish Orange (M. 5B3) to Brownish Red (M. 8C7) or Saffron to Bay (Rayner). Colonies on CYA growing restrictedly, attaining a diam of 10-12 mm within 7 days and up to 37-40 mm within 21 days at 25° C, floccose, more or less radially sulcate, thin, with more abundant production of yellow ascomata; conidiogenesis inconspicuous or lacking; exudate clear, centrally scattered; odor musty; reverse Light Brown (M. 6D5) to Reddish Brown (M. 8D5) or Fulvous to Bay (Rayner). Colonies on MEA growing as on CYA, floccose, convolute, consisting of a thin basal felt; ascomata produced in a dense layer on the felt, overgrown by a loose network of aerial hyphae, Pastel Yellow (M. 1A4) or Sulphur Yellow (Rayner); conidiogenesis lacking; odor musty; reverse Light Brown (M. 6D5) to Greyish Orange (M. 6B5) or Fulvous to Ochreous (Rayner). Colonies on cornmeal agar growing rather restrictedly, attaining a diam of 12-13 mm within 7 days and up to 42 mm within 21 days at 25°C, plane, thin, with vegetative mycelium submerged, White to Yellowish White (M. 2A2) or Straw (Rayner); ascomata tardily produced; conidiogenesis inconspicuous or lacking; exudate clear; odor musty; reverse uncolored.

Ascomata non-ostiolate, discrete or confluent, maturing slowly within 28 days, sulphur yellow, globose to subglobose, mostly 120-350 µm in diam, soft, loosely covered by radiate, yellow, encrusted, branched, septate hyphae up to 250 µm long; ascomatal wall composed of a loose network of cream-colored, encrusted, densely interwoven hyphae measuring 1-2 µm in diam. Ascomatal initials composed of short clavate ascogonia, 15-20 µm long and 4 µm wide, around which thick antheridia coil tightly several times. Asci in short chains, 8-spored, globose to broadly ovoidal, 8-11 x 7.5-9 µm, evanescent. Ascospores hyaline to pale yellow, globose to subglobose, 2.5-3 µm in diam, sometimes broadly ovoidal, 3-3.5 x 2.5-3(-3.5) µm, more or less thick-walled, spinulose with spines up to 0.5 µm long.

Conidiophores arising from aerial hyphae; stipes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10 µm
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Fig. 3. *Talaromyces emodensis*, SUM 3025.
A. Asci. B. Ascospores. C. Ascomatal initials.
D. Penicilli. E. Conidia.

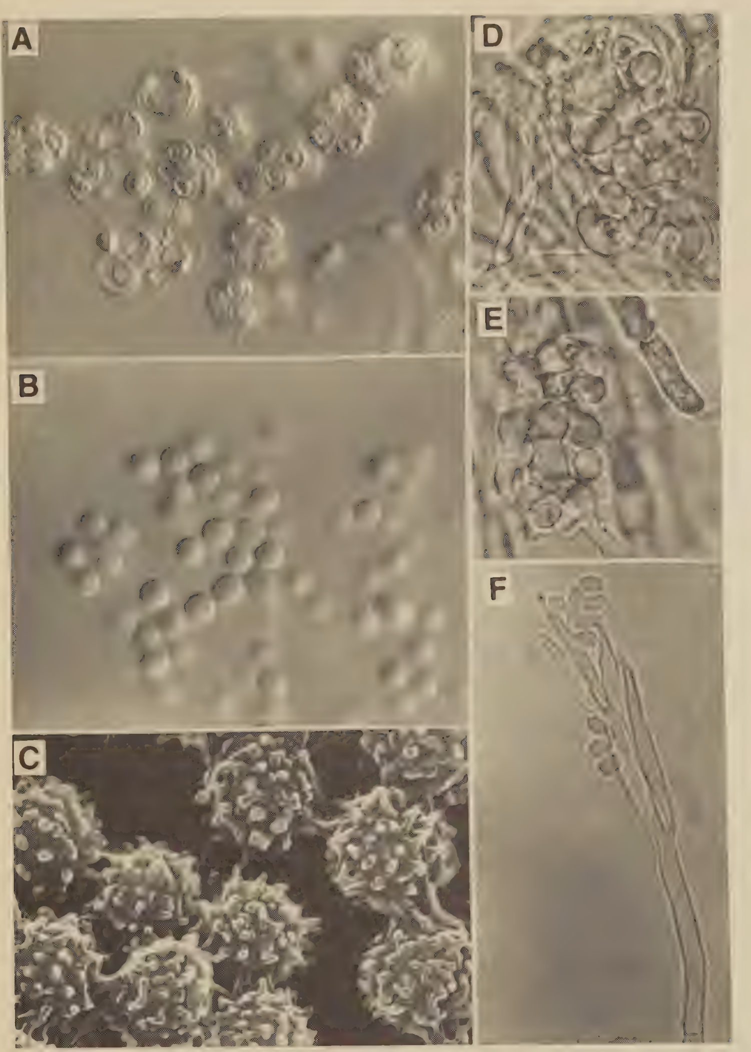


Fig. 4. *Talaromyces emodensis*, SUM 3025. A. Asci, x 1200. B. Ascospores, x 1200. C. Ascospores (SEM), x 6000. D and E. Ascomatal initials, x 1200. F. Penicillus, x 1200.

short, 18-60 x 2-2.5 µm, hyaline, smooth-walled, septate. Penicilli monoverticillate but irregular and often fragmentary. Branches sometimes present, 15-25 µm long. Phialides in verticils of 2-3, lanceolate, 10-17.5 x 2-3 µm. Monophialides cylindrical, 20-60 x 2-2.5 µm. Conidia hyaline, ovoidal to ellipsoidal, 3-4 x 1.5-3 µm, smooth-walled, in short disordered chains. Anamorph often lacking.

Major ubiquinone: Q-10(H_2).

At 37°C, growth is restricted.

Specimens examined: SUM 3025 (holotype), in dried culture isolated from paddy soil, Tau Daha, Kathmandu Valley, Nepal, Sept. 4, 1986; SUM 3019, in dried culture isolated from soil, Ring Road, Kathmandu, Nepal, Sept. 30, 1986. The holotype has been deposited with the Natural History Museum and Institute, Chiba, Japan.

Talaromyces emodensis is placed in the series *Lutei* (Pitt, 1979) on the basis of its slow growth upon common media and its bright yellow colony and ascomata. The small subglobose ascospores and simple penicilli closely resemble those of *Talaromyces tardifaciens* Udagawa (vide post). Nevertheless, *T. emodensis* is distinguished from the latter by its ascomatal initials which develop from the paired gamentangia (similar to *T. stipitatus* C.R. Benjamin in the series *Flavi*), its sulphur yellow ascomata, its large asci and the rather ovoidal conidia.

Talaromyces tardifaciens Udagawa, sp. nov. Figs. 5, 6

Coloniae in agaro Czapekii valde restrictae. Coloniae in CYA restrictae, velutinae, planae, ex mycelio basali coacto tenuiter constantes, ascomatibus abundantibus formantes, aurantiaceae; conidiogenesis sparsa et inconspicua; reversum armeniacum vel olivaceo-nigrum. Coloniae in MEA paulo effusae, ex mycelio basali coacto tenuiter constantes, plus minusve floccosae, ascomatibus abundantibus formantes, granulares, pallide flavae vel luteae; conidiogenesis sparsa et inconspicua; reversum aurantiacum vel armeniacum. Coloniae in agaro farinae avenaceae restrictae, floccosae, pallide flavae vel stramineae vel luteolae, ascomatibus abundantibus formantes; conidiogenesis sparsa; reversum incoloratum.

Ascomata non-ostiolata, saepe confluentia, tarde maturescentia, rubro-flava vel atroaurantiaca, globosa vel subglobosa, 200-380 µm diam, mollia, mycelio denso flavo incrustato sinuato obtecta; paries ex hyphis laxis tenuibus ramosis septatis intricatis compositus. Asci breviter catenulati, 8-spori, globosi vel ovoidei, 6-8 x 6-7 µm, evanescentes. Ascosporae hyalinae, subglobosae, 2.5-3 µm diam, vel late ovoideae, 3-3.5 x 2-3 µm, spinulosae. Status anamorphus: *Penicillium tardifaciens*.

Ubiquinonum majus: Q-10(H_2).

Holotypus SUM 3017, colonia exiccata in cultura ex solo agresti, Kathmandu, in Nepalia, 4.ix.1986, a S. Udagawa isolata et ea collectione fungorum, Musei et Instituti Historiae Naturalis Chiba (CBM) conservata.

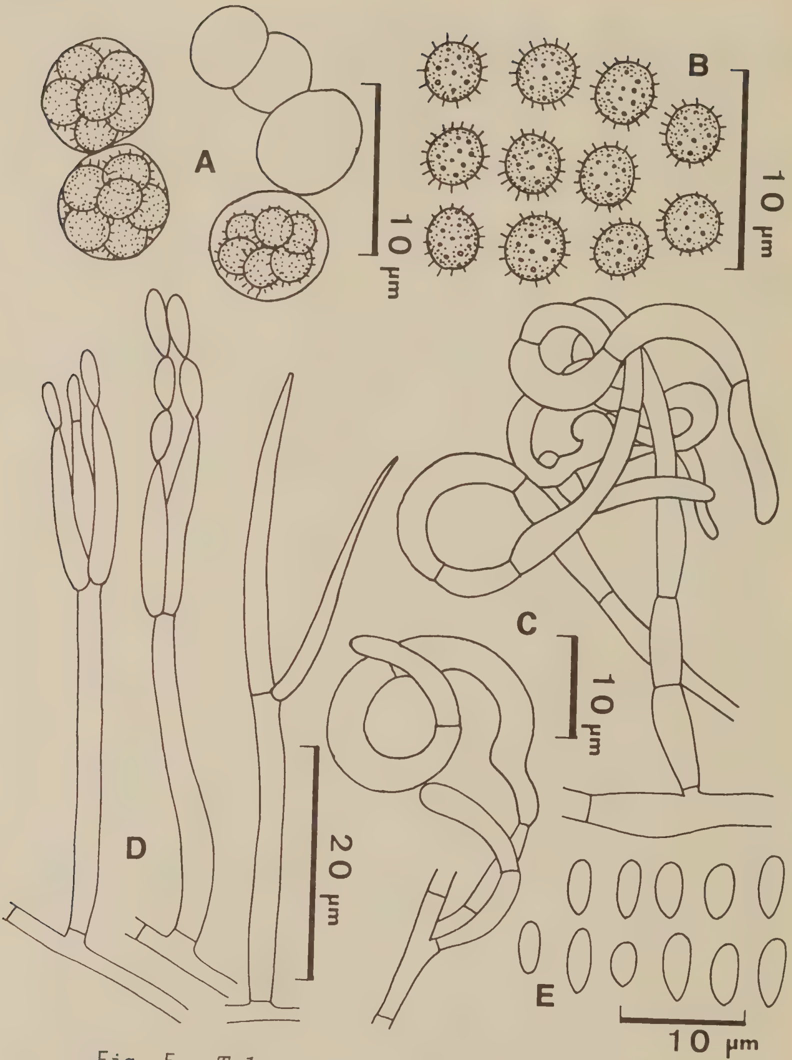
Etymology: from Latin, *tardus*=slow and *-faciens*=producing, referring to the slow development of the ascomata on the medium.

Anamorphosis: *Penicillium tardifaciens* Udagawa, anam. nov.

Conidiophora ex hyphis aeriis oriunda; stipites 20-37.5 x 2-2.5 µm, hyalini, leves, septati. Penicilli plerumque monoverticillati. Phialides 2-3 verticillatae, acerosae, 10-17.5 x 2-2.5 µm, saepe solitariae, ad 30 µm longae. Conidia hyalina, ellipsoidea vel cylindracea, 3-6 x 1.5-2.5 µm, saepe apice acuta, levia, in catenis brevibus connexa. Status teleomorphus: *Talaromyces tardifaciens*.

Holotypus SUM 3017, loc. cit.

Colonies on Czapek agar growing very slowly, attaining a diam of 3-5 mm within 7 days at 25°C, with surface developing only white mycelium and sparse conidia, failing to produce mature ascomata even within 21 days. Colonies on CYA growing restrictedly, attaining a diam of 5 mm within 7 days and up to 17 mm within 21 days at 25°C, velvety, plane, consisting of a thin basal felt, in which abundant ascomata are embedded, Orange (M. 6A7) in color; conidiogenesis sparse, not sufficiently produced to influence the colony appearance; margins thin, somewhat irregular; odor slightly earthy; reverse Orange to Dark Green (M. 6B7-25F4) or Apricot to Olivaceous Black (Rayner). Colonies on MEA growing rather rapidly, attaining a diam of 15 mm within 7 days and up to 55 mm within 21 days, consisting of a thin basal felt, with surface appearing more or less floccose, commonly raised in central area, producing abundant ascomata in granular appearance, Light Yellow (M. 4A5) or Luteous (Rayner) in color; conidiogenesis sparse and not affecting the colony appearance; margins broad and thin; odor musty; reverse Orange (M. 5A7) or Apricot (Rayner). Colonies on oatmeal agar growing restrictedly, attaining a diam of 15 mm within 7 days at 25°C, floccose, Light Yellow (M. 2A5) or Straw to Pale Luteous (Rayner) colored from the abundant ascomata borne slowly in a loose mycelial felt; conidiogenesis sparse; reverse


A
B
10 µm
10 µm
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10 µm
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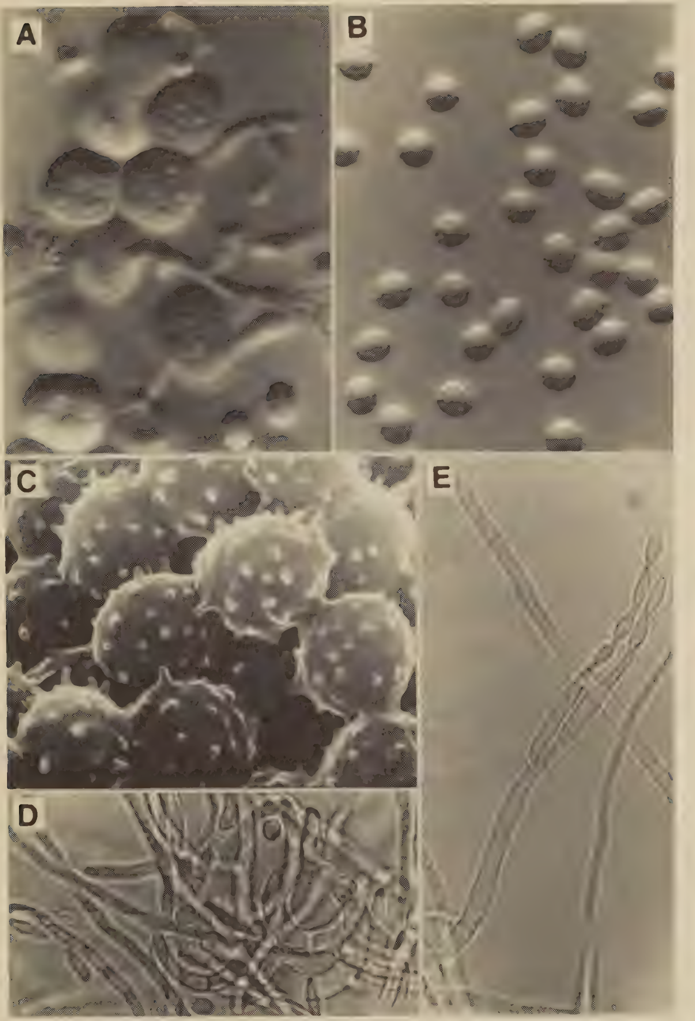
20 µm
E
10 µm

Fig. 5. *Talaromyces tardifaciens*, SUM 3017. A. Asci. B. Ascospores. C. Ascomatal initials. D. Penicilli. E. Conidia.

Fig. 6. *Talaromyces tardifaciens*, SUM 3017. A. Asci, x 2000. B. Ascospores, x 2000. C. Ascospores (SEM), x 7000. D. Ascomatal initial, x 1300. E. Penicillus, x 1300.


A
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uncolored.

Ascomata non-ostiolate, often confluent, maturing slowly within 21 days or more, reddish yellow to deep orange, globose to subglobose, 200-380 µm in diam, soft, covered by a dense weft of straight or sinuous, yellow-encrusted hyphae; ascomatal wall composed of a loose network of thin, branched, interwoven, 1-2.5 µm diam hyphae; ascomatal initials distinct, started as side branches of the aerial hyphae, composed of large, terminally looped, swollen, septate hyphae, developing into several loose coils in a helical pattern. Asci in short chains, 8-spored, globose to ovoidal, 6-8 x 6-7 µm, evanescent. Ascospores hyaline, small, subglobose, 2.5-3 µm in diam, or broadly ovoidal, 3-3.5 x 2-3 µm, spinulose with very small spines.

Conidiophores arising from aerial hyphae; stipes 20-37.5 x 2-2.5 µm, hyaline, smooth-walled, septate. Penicilli monoverticillate, but irregular and often fragmentary. Phialides in verticils of 2-3, lanceolate, 10-17.5 x 2-2.5 µm, hyaline, smooth-walled. Monophialides cylindrical, 12.5-30 x 2-2.5 µm. Conidia hyaline, ellipsoidal to cylindrical, 3-6 x 1.5-2.5 µm, often pointed at one or both ends, smooth-walled, in short chains.

Major ubiquinone: Q-10(H_2).

At 37°C, growth is nil.

Specimens examined: SUM 3017 (holotype), in dried culture isolated from paddy soil, Bhaktapur, Nepal, July 21, 1986: SUM 3029, in dried culture isolated from soil, Ring Road, Kathmandu, Nepal, Sept. 30, 1986. The holotype has been deposited with the Natural History Museum and Institute, Chiba, Japan.

Talaromyces tardifaciens is characterized particularly by its more restricted growth upon CYA; by its orange-colored ascomata; by its small subglobose ascospores and by its strongly ellipsoidal conidia in the simple penicilli. This species is also assigned to the series *Lutei* of *Talaromyces* (Pitt, 1979). Within the series, it appears closest to *Talaromyces rotundus* (Raper et Fennell) C. R. Benjamin (Raper and Fennell, 1948; Stolk and Samson, 1972; Pitt, 1979), but differs in the more delayed maturing (21 days or more) of its ascomata, in the pattern of its ascomatal initials, in the small dimensions of its asci and ascospores, and its production of very few phialides as reduced penicilli.

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GYMNOSTELLATOSPORA, A NEW GENUS OF THE MYXOTRICHACEAE

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ABSTRACT

Gymnostellatospora japonica Udagawa, Uchiyama et Kamiya, a new genus and species of the Myxotrichaceae, is described and illustrated, having been isolated from forest and grassland soils in the Tokyo megalopolis, Japan. The fungus is considered to be distinct from other gymnoascaceous genera by the ascospores with three prominent longitudinal crests.

Key Words: ascomycete, Myxotrichaceae,
Gymnostellatospora, taxonomy,
soil fungus, Onygenales.

During an exploratory survey of soil-borne ascomycetes as producers of metabolites useful to the pharmaceutical industry, an interesting gymnoascaceous fungus was recently isolated from soil samples collected from two cities in the Tokyo megalopolis. The fungus produces a grayish orange mass of confluent ascomata over the surface of small colonies on potato-dextrose agar and diluted Sabouraud agar (Takashio, 1972). The white to yellowish brown, ascomatal peridium is composed of a fragile network of brown anastomosed hyphae, which at maturity form an incompositoperidium (Currah, 1985). The ascospores are fusiform and ornamented with longitudinal crests, reminiscent of the ascospore morphology in *Emericellopsis* in the Pseudeurotiaceae (Malloch and Cain, 1970). Distinctive characters of the ascomata and ascospores seems to exclude the fungus from the described genera in the Onygenales (Currah, 1985), and we therefore propose a new genus to accomodate this fungus.

MATERIALS AND METHODS

Strains. The three isolates, BF 24290, BF 37158 and BF 37160, examined in this study. These strains are maintained as living cultures in the Tsukuba Research Institute, Banyu Pharmaceutical Co., Ltd., Tsukuba-shi, Japan.

Media. Cultures were grown in the dark, on several media including: phytone yeast extract (PYE) (Carmichael, 1962), potato-dextrose (PDA), yeast-starch (YpSs) (Emerson, 1941), diluted Sabouraud (Takashio, 1972), and cellulose agars. Dense growth on the cellulose agar, composed of 10 g powdered cellulose, 1 g NH_4NO_3, 0.5 g K_2HPO_4, 0.5 g $MgSO_4{\cdot}7H_2O$, and 20 g agar per liter of infusion from 1 kg soil (Udagawa, 1960), was recorded as indicating cellulolytic ability. Colors designated are from the Kornerup and Wanscher (1978) color standard and the Rayner (1970) color chart, and are referred to with the letters M and R, respectively.

Scanning electron microscopy. Scanning electron microscopy (SEM) was performed using a Hitachi Model S-4100 SEM. For SEM, ascospores were fixed in 0.5% osmium tetroxide, dehydrated in a graded alcohol series, critical-point dried, and sputter coated with platinum-palladium.

Ubiquinone analysis. Extraction, purification, and determination of ubiquinones from the liquid cultures (a medium composed of 5 g malt extract, 3 g yeast extract, and 30 g gulcose per liter of distilled water) of the three strains by high-performance liquid chromatography were carried out as described by Kuraishi et al. (1985).

RESULTS AND DISCUSSION

Gymnostellatospora Udagawa, Uchiyama et Kamiya, gen. nov.

Ascomata discreta vel confluentia, plus minusve globosa, alba dein flavo-brunnea vel rubro-brunnea; paries ex hyphis ramosis et anastomosantibus, asperulatis, incrassatis, brunneis compositus, postea incompleto-reticulum formans; appendices indistinctae, simplices, breves, hyalinae vel dilute brunneae, asperulatae, septatae, rectae vel flexae. Asci 8-spori, globosi vel ovoidei, evanescentes. Ascosporae unicellulares, fusiformes, hyalinae vel dilute flavae, cristis longitudinalibus praeditae, cum superficie parum costatae. Anamorphosis abest.

Species typica: *Gymnostellatospora japonica* Udagawa, Uchiyama et Kamiya.

Etymology: Latin, *gymno-* =naked; *stellatospora*=stellate spores, referring to the characteristics of the ascomata and the ascospores.

Ascomata discrete or confluent, more or less globose, at first white, then in yellowish brown or reddish brown shades; peridium composed of a network of branched and anastomosed more or less at right angles, asperulate, thick-walled, brown hyphae, forming an incompositoperidium at maturity; appendages indistinct from the peridial elements, simple, short, hyaline to pale brown, asperulate, septate, straight or bent. Asci 8-spored, globose or ovoidal, evanescent. Ascospores one-celled, fusiform, hyaline to pale yellow, with narrow longitudinal crests, with convex surface faintly roughened by low ribs. Anamorph lacking.

Gymnostellatospora japonica Udagawa, Uchiyama et Kamiya, sp. nov. (Figs. 1, 2)

Coloniae in agaro decocto tuberorum aliquanto effusae, granulosae, conspicue rugosae et radiatim sulcatae, primum albae vel dilute flavae, dein griseo-flavae vel bubalinae vel electrinae, numerosis ascomatibus formantes; reversum brunneo-aurantiacum vel flavo-brunneum, dein atrobrunneum vel sanguineum.

Ascomata superficialia, discreta vel confluentia, vulgo globosa, 100-200 (-280) µm diam, flavo-brunnea vel rubro-brunnea, tarde maturescentia; hyphae peridii flavo-brunneae vel dilute brunneae, incrassatae, asperulatae, septatae, ramosae et anastomosantes, postea incompleto-reticulum formantes; appendices indistinctae, hyalinae vel dilute brunneae, breves, fere 20-80 µm longae, asperulatae, septatae, rectae vel saepe flexae. Asci 8-spori, globosi vel subglobosi vel ovoidei, 5-8 × 5-7 µm, evanescentes. Ascosporae fusiformes, 3-4 × 1.5-2 µm, utrinque acuminatae, hyalinae vel dilute flavae, cristis (2-) 3 longitudinalibus praeditae, cum superficie parum costatae. Mycelio vegetativo ex hyphis hyalinis vel dilute flavis, ramosis, levibus, septatis, 1-2 µm diam composito. Anamorphosis abest.

Ubiquinonum majus: Q-10(H_2).

Holotypus BF 24290, colonia exiccata in cultura ex solo sylva, Yokohama, in Japonia, 18.ii.1990, a S. Kamiya isolata et ea collectione fungorum, Musei et Instituti Historiae Naturalis Chiba (CBM) conservata.

Etymology: Latinized from the name Japan, referring to the country of the type locality.

Colonies on PYE growing restrictedly, attaining a diam of 22-24 mm within 21 days at 25°C, velvety, radially sulcate, consisting

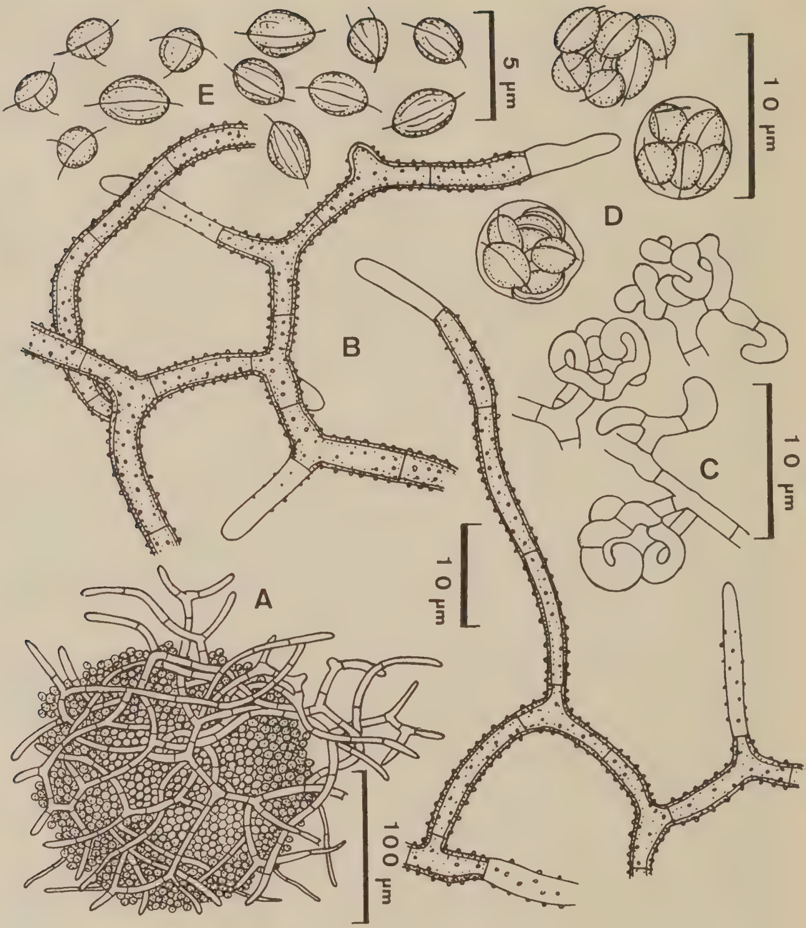

Fig. 1. *Gymnostellatospora japonica*, BF 24290.
A. Ascoma. B. Peridial hyphae with appendages. C. Ascomatal initial. D. Asci. E. Ascospores.

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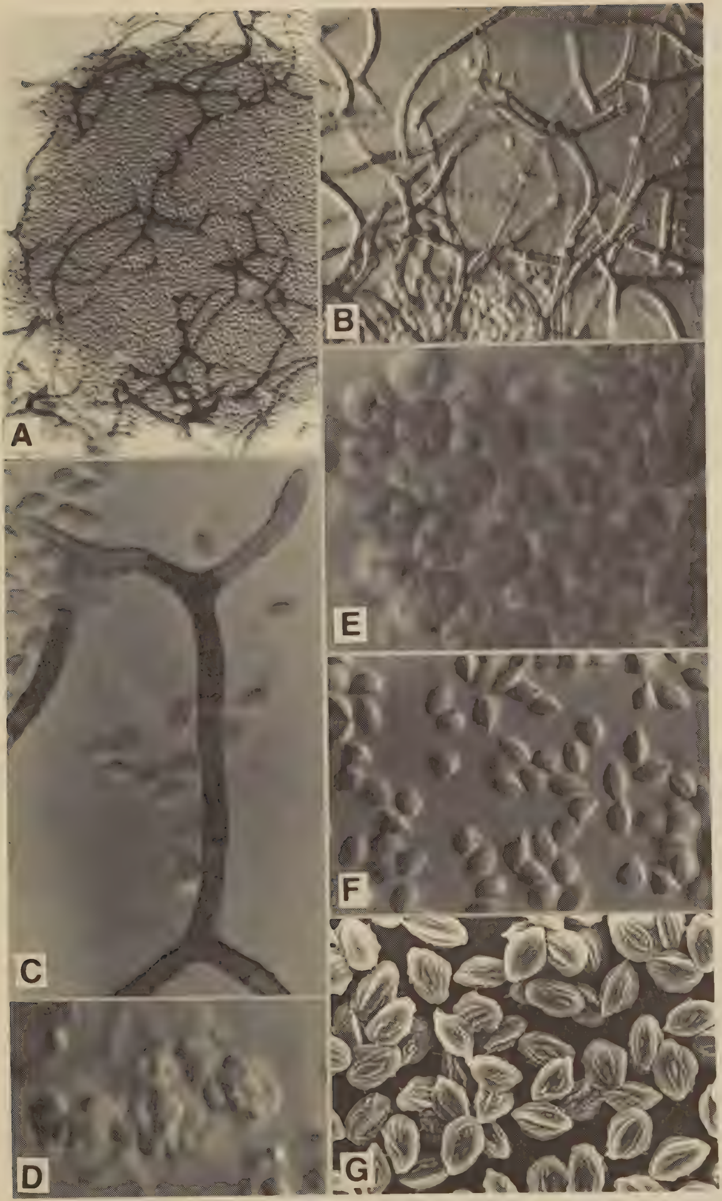
Fig. 2. *Gymnostellatospora japonica*, BF 24290.
A. Ascoma, ×340. B. Peridial hyphae, ×720. C. Peridial hyphae with appendage, ×1800. D. Ascomatal initials, ×1800. E. Asci, ×1600. F. Ascospores, ×1800. G. Ascospores (SEM), ×3000.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of a thin basal felt, white at first, then becoming Olive Brown to Light Brown (M. 4D4-7D5) or Olivaceous Buff to Cinnamon (R) ; ascomata absent; reverse and agar Light Brown to Reddish Brown (M. 5D4-8D5), or Isabelline to Sepia (R).

Colonies on PDA growing rather rapidly, attaining a diam of 28-30 mm within 21 days at 25°C, granular in appearance due to the formation of abundant ascomata, conspicuously wrinkled and radially sulcate, zonate, consisting of rather thick basal felt, centrally raised up to 3 mm high, White to Pale Yellow at first, then becoming Greyish Yellow (M. 4B3-5) or Buff to Amber (R); exudate present, scattered, Salmon; reverse Brownish Orange to Yellowish Brown (M. 5C6-5D5), or Amber to Cinnamon (R), later becoming Dark Brown (M. 9F5) or Blood Colour (R); soluble pigment diffusing into the agar, Reddish Brown.

Colonies on YpSs agar growing rather restrictedly, attaining a diam of 26-28 mm within 21 days at 25°C, velvety to slightly floccose, deeply radially sulcate, more or less zonate, consisting of a thin basal felt, White to Greyish Yellow (M. 3B6) or Amber (R), becoming Light Yellow (M. 3A5) or Straw to Pure Yellow (R), producing numerous immature ascomata; reverse Light Yellow to Pale Orange (M. 4A4-5A3) or Pale Luteous to Salmon (R).

Colonies on diluted Sabouraud agar growing restrictedly, attaining a diam of 18 mm within 21 days at 25°C, granular in appearance, plane, thin, vegetative mycelium submerged, producing abundant ascomata on the agar surface, Greyish Orange (M. 6B4) or Buff to Rosy Buff(R); reverse Light Brown (M. 6D5) or Dark Brick to Cinnamon (R).

Ascomata superficial, discrete or confluent, usually globose, 100-200 (-280) µm diam excluding the appendages, yellowish brown to reddish brown, maturing slowly within 28 days; peridial hyphae yellowish brown to pale brown, thick-walled, asperulate, septate, 2-3 µm diam, branched and anastomosed, forming an incomplete network in age; appendages indistinct from the peridial elements, hyaline to pale brown, short, mostly 20-80 µm long, asperulate, septate, straight or often bent, arising as the free apices of the peridial hyphae. Asci 8-spored, globose to subglobose or ovoidal, 5-8 × 5-7 µm, evanescent. Ascospores fusiform, 3-4 × 1.5-2 µm, acuminate at both ends, hyaline to pale yellow, with (2-) 3 wing-like external crests which are longitudinal (up to 1 µm wide), with convex surface roughened by low ribs (under SEM).

Vegetative mycelium composed of hyaline to pale yellow, branched, smooth-walled, septate, 1-2 µm diam hyphae, sometimes forming bundles; ascomatal initials irrregular, produced as swollen side branches of vegetative hyphae, consisting of a tightly coiled ascogonium, developing several knots; anamorph not seen.

Cellulolytic.

Major ubiquinone: Q-10(H_2).

At 37°C, growth is nil.

Specimens examined: a dried culture isolated from forest soil, Seya-ku, Yokohama-shi, Kanagawa-pref., Japan, 18 February 1990, BF 24290, holotype; and dried cultures isolated from grassland soil, Sadamine-pass, Chichibu-shi, Saitama-pref., Japan, 13 June 1992, BF 37158 and BF 37160. The type specimen is deposited in the Natural History Museum and Institute, Chiba, Japan (CBM).

The general characteristics of *Gymnostellatospora*, especially in having fusiform and ridged ascospores, suggest a relationship with the genera *Byssoascus*, *Myxotrichum* and *Pseudogymnoascus* in the Myxotrichaceae as recently defined (Currah, 1985). *Myxotrichum* species produce dark-colored ascomata with well-developed appendages, while the peridial elements in the ascomata of *Byssoascus* are a telaperidium-type (Orr et al., 1963; Barron and Booth, 1966; Currah, 1985). The yellowish or reddish brown coloration of the ascomata and the network of the peridial hyphae from which short, simple and asperulate appendages originate are rather similar to those of *Pseudogymnoascus* (Samson, 1972; Orr, 1979; Currah, 1985). However, the ascospores of *Pseudogymnoascus* are smooth-walled, and the peridial hyphae are an entirely reticuloperidium-type (Currah, 1985). The ascospore ornamentation in the former two genera of the Myxotrichaceae is characterized by the presence of ridges running longitudinally or slightly obliquely along the length of the ascospores, but no species have been described with ascospores with wing-like crests.

Few data are available concerning distribution of ubiquinone systems in the members of the Onygenales, but ubiquinone Q-10(H_2) has been found in *Myxotrichum cancellatum* and *Pseudogymnoascus roseus*, hitherto the only investigated species of the Myxotrichaceae (Kuraishi et al., 1985). The major ubiquinone of all isolates of *Gymnostellatospora japonica* was determined as Q-10(H_2). This supports a placement of the genus in the Myxotrichaceae.

In the Trichocomaceae (Malloch and Cain, 1972; Benny and Kimbrough, 1980), at least four genera produce ascomata similar to those of most members of the Onygenales, since their coverings consist of hyphal networks, which may be loose or even absent, viz. *Byssochlamys*, *Hamigera*, *Talaromyces* and *Warcupiella*. These genera can easily be separated from the members of the Onygenales by their phialidic anamorphs. Although *Gymnostellatospora* has no anamorph, the ascomata with the incompositoperidium-type wall prevent its inclusion in the Trichocomaceae. Nevertheless, it is interesting that *Talaromyces unicus* Tzean, Chen et Shiu (Tzean et al., 1992) has flanged ascospores similar to those of *Gymnostellatospora*.

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SYSTEMATIC AND BIOLOGICAL STUDIES IN THE BALANSIEAE AND RELATED ANAMORPHS. IV. HOST-PATHOGEN RELATIONSHIP OF ARISTIDA PURPURASCENS AND BALANSIA ARISTIDAE

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ABSTRACT

A brief review of known host-pathogen relationships within the Balansieae is provided for purposes of comparison. The precise nature of the association between *Balansia aristidae* (Atk.) Diehl and its host, *Aristida purpurascens* Poir, is newly reported. The endophytic, systemic habit and the distribution of its hyphae in host tissue preceding and following egress to form *Ephelis* macroconidial and *Balansia* teleomorph stromata were determined by histological techniques. Unlike the condition reported in some associations, the host is notably stunted in this relationship.

INTRODUCTION

Host-pathogen relationships between members of the tribe Balansieae and the various grasses and sedges on which they occur are diverse, ranging from epiphytic to endophytic and from localized to systemic habits. Some of these fungi are highly host-specific, occurring on single grass species. Others have a host range of various dimensions from a single grass genus to several, or even to members of different grass subfamilies. In terms of their effects on host plants, some are destructive pathogens, others are relatively benign, and a few are mutualists. The basis for mutualism has been suggested to be the acquisition by grasses of a chemical defense against herbivory in the form of toxic alkaloids produced by their endophytic fungi (Clay, 1988). Mutualism probably has its origins in parasitism (Boucher *et al.*, 1982; Clay, 1988) and this type of relationship between grasses and clavicipitaceous fungi is thought to be the result of a long association characterized by progressive reduction in virulence and a lessening of detrimental effects on the host over time. Although a number of researchers have, over the last two decades, investigated the nature of the association between some of these fungi and their hosts, very few

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species have thus far been studied in any detail. Information on the majority is either entirely lacking or insubstantial. Most species have been found to grow endophytically to varying extents within their hosts, but a few, of which *Atkinsonella hypoxylon* (Peck) Diehl, *A. texensis* (Diehl) Leuchtmann & Clay, *Balansia cyperi* Edg., and *Myriogenospora atramentosa* (Berk. & Curt.) Diehl are the best-known examples, grow epiphytically on leaves and inflorescences (Luttrell and Bacon, 1977; Leuchtmann and Clay, 1988).

Grass-infecting Balansieae are thought to have co-evolved with their hosts (White and Morgan-Jones, 1992). An epiphytic habit is considered to be the more primitive, although in this type of host-fungus relationship interactions may be complex, as in *A. hypoxylon* and *M. atramentosa*. The earliest evolved members of the group are believed to have been associated with bambusoid hosts, whereas those of more recent origin occur on pooids. Species such as *Balansia linearis* (Rehm.) Diehl, *Balansiopsis guaduae* (Rehm.) Höhnel and *Balansiopsis pilulaeformis* (Berk. & Curt.) Diehl may be among the oldest, followed by taxa that occur on sedges and arundinoid hosts (White and Morgan-Jones, 1992). The largely endophytic taxa, which include the majority of the species of *Balansia* Speg. and *Epichloe* (Fr.) Tul., can be viewed as variously reduced forms that predominantly exist as intercellular mycelium in host tissues and only egress to form external conidiomatal and perithecial stromata. In the case of *Acremonium* anamorphs, the mycelium is totally and permanently endophytic. No conidiation is known to occur in nature (White and Morgan-Jones, 1987) and the fungi are maternally transmitted in seed (Latch and Christensen, 1982; Siegel *et al.*, 1985). Species associated with the Poaceae, including *Epichloe typhina* (Pers.:Fr.) Tul. and related *Acremonium* endophytes, may be the most recently evolved.

Among the Balansieae, different adaptive changes in host-fungus relationships and life cycles are apparently common. A progressive trend toward a systemic endophytic growth habit is evident (Clay, 1988; White and Morgan-Jones, 1992). There is an accompanying range of host morphological changes and reduction from dwarfing or deformity to sterility, to a totally unaltered condition, other than, perhaps, energy loss. In the case of species infecting bambusoids, host plant growth may be appreciably affected, sometimes resulting in developmental malformations. In *Balansia linearis*, whose stromata occur on culms and abaxial leaf surfaces, the terminal leaves of infected hosts, including *Olyra micrantha* H.B. & K. and species of *Chusquea* Kunth and *Pariana* Aubl., become spirally inrolled, usually without reduction in length. In *Chusquea*, distinct brooming of the shoot distally and even dwarfing of the leaves can occur (Diehl, 1950). Tight inrolling of bambusoid leaves is, because of their width, a striking symptom of infection, in sharp contrast to the morphology of healthy leaves. As a result of the process, only the abaxial surface remains exposed. In *B. linearis*, the black perithecial stroma emerge by lengthwise splitting of the host epidermis. This is very different from the habit of many other endophytic Balansieae where egress occurs by single or small groups of hyphae emerging between epidermal cells without overt disruption. Höhnel (1910) proposed the generic name *Linearistroma* Höhn. for this species due to its linear stromata bearing perithecia in two rows. This feature does not, however, appear to be consistent (Diehl, 1950). Differences in host relationship, the *Ephelis* anamorph, as well as possession of a prominent ascus cap, unlike other species of *Balansia*, may be sufficient reasons for accepting its segregation.

A pronounced witches'-broom effect on its hosts, *Bambusa arundinacea* Willd., *Chusquea uniflora* Stend. and *Guadua tagoara* (Nees) Kunth, is also produced by *Balansiopsis guaduae* (Möller, 1901; Viégas, 1944). Diehl (1950) reported infection by *B. pilulaeformis* to suppress inflorescence development in species of *Paspalum* L., cause terminal leaf deformity and absence of ligules, and result in a tendency of culm growth toward brooming. Rykard *et al.* (1984) described primary stromata of this species, on *Chasmanthium laxum* (L.) Yates, to bind branches of unexpanded inflorescences and to resemble those of *Atkinsonella hypoxylon*. Further details of host-fungus interactions in these species, considered by White and Morgan-Jones (1992) to possibly represent evolutionary 'prototypes', are not known.

Atkinsonella hypoxylon, a species that is host-specific to *Danthonia spicata* (L.) Beauv., *A. texensis*, a closely similar species occurring on *Stipa leucotricha* Trin. & Rupr., and *Balansia cyperi*, a pathogen of species of *Cyperus* L., are epiphytes occurring in close proximity to meristems, young leaves and inflorescences of their hosts (Leuchtmann and Clay, 1988). Likewise, *Myriogenospora atramentosa* is epiphytic on leaves of a number of host grasses (Rykard *et al.*, 1985). In both *A. hypoxylon* and *A. texensis* superficial hyphal mats develop proximal to the meristem of tiller buds, on the surface of the meristematic region in young tillers and in spaces between the base of young leaves (Leuchtmann and Clay, 1988). No penetration of any host tissue occurs. Following intercalary shoot growth, rapid fungal proliferation occurs forming a dense mycelial biomass, the primary stroma, around a developing inflorescence and extending inbetween leaves. The relationship between *B. cyperi* and its hosts is essentially similar to that of the two species of *Atkinsonella* Diehl although small differences in location and degree of development of the initial hyphal biomass are apparent (Leuchtmann and Clay, 1988). In all three fungi, enclosure of host culm apices by fungal stromata results in aborted inflorescences.

Myriogenospora atramentosa, occurs on a number of grasses, including species of *Andropogon* L., *Eragrostis* Wolf, *Eremechloa* Buse, *Panicum* L., and *Paspalum* L. (Rykard *et al.*, 1982, 1985), and grows entirely superficially on leaves causing "black streak" or "tangle-top" disease (Hanlin and Tortolero, 1990). Infected plants tend to be somewhat shorter than uninfected ones (Diehl, 1934; Luttrell and Bacon, 1977). Although the fungus does not enter the host tissue, appreciable carbohydrate loss occurs from hypertrophied epidermal cells beneath the stromata (Smith *et al.*, 1985).

In both *Balansia epichloe* (Weese) Diehl and *B. henningsiana* (Möell.) Diehl endophytic mycelium grows intercellularly in leaf and culm tissues, including the pith (Rykard *et al.*, 1985; Leuchtmann and Clay, 1988; White and Owens, 1992). Within leaves, hyphae of *B. epichloe* proliferate in mesophyll tissues and between cells of vascular bundles, including phloem and xylem (White and Owens, 1992). Hyphae emerge from between host epidermal cells or between guard cells through stomata, and produce superficial stromata (Rykard *et al.*, 1985). A single stroma is connected to internal mycelium by numerous hyphae, sometimes referred to as hyphal bridges (White and Owens, 1992). In *B. epichloe* some emergent hyphae grow laterally below the cuticle which results in localized partial detachment of this waxy layer from the subtending epidermis (Rykard *et al.*, 1985). Some degradation of the cuticle becomes evident and it is thought that stromal development is sustained by not only nutritional resources from within leaves but by products of cuticle decomposition. *Epichloe typhina* and related *Acremonium* anamorphs are partially or entirely endophytic within plants (Sampson, 1933; White and Morgan-Jones, 1987). In the former, a decreased tendency to form stromata has been detected, the fungus relying instead on seed transmission (White *et al.*, 1991). On some hosts, such as *Festuca rubra* L., stromata are rarely formed (Sampson, 1933), on others, such as *Agrostis hiemalis* (Walter) B.S.P., only a small percentage of culms may bear stromata (White and Chambless, 1991). The mycelium of *E. typhina* is systemic, largely intercellular, and located predominantly in the pith although intracellular penetration of parenchyma and vascular tissue, including xylem vessels, may occur in proximity to inflorescence primordia (Sampson, 1933). Prior to the elaboration of primary anamorph stromata, hyphal egress and mycelium build-up occurs around leaf sheaths, binding them together and preventing inflorescence emergence (Sampson, 1933; Kirby, 1961). In some susceptible grass species, only the panicle or part of the panicle is invested in a stroma (Benedict, 1928; Sampson, 1933).

In other associations, in sharp contrast, plant growth and seed production can be enhanced by systemic fungal endophytes belonging to this complex (Clay, 1988). Grasses infected by species of *Acremonium* Link section *Albo-lanosa* Morgan-Jones and W. Gams are known to grow significantly better than when uninfected (Latch *et al.*, 1985; Clay, 1987). Plants of *Agrostis tenuis* Sibth. infected by *Epichloe typhina* can be vegetatively vigorous (Bradshaw, 1959).

During the course of collecting species of *Balansia* in the southeastern United States, we have encountered several populations of *B. aristidae* on *Aristida purpurascens* in Alabama. This has afforded us an opportunity to study the host-fungus relationship which is reported herein.

MATERIALS AND METHODS

Plants of *Aristida purpurascens* bearing mature, perithecial stromata of *Balansia aristidae* were collected at a site in Montgomery County, Alabama, during early to mid summer of 1990 and 1991. Voucher specimens from these collections have been deposited in the Auburn University Mycological Herbarium (AUA) and at BPI. Infected plants were transplanted into 15 cm diameter plastic pots containing local sandy, red clay soil and grown in a Conviron growth chamber to optimize conditions for growth. An environment of 90% relative humidity and alternating 12-hour light/dark periods (provided by incandescent and fluorescent lights) at temperatures of 32° C and 24° C respectively, was maintained. Peters 20-20-20 plant food was applied at half the recommended rate twice per month. The test plants were maintained and observed for one to two years. Some plants were maintained in pots outdoors under natural conditions for the same time period.

Leaf, culm, and stromal tissue were sampled at different anatomical locations and at different stages of development from pot grown plants. Fixation, dehydration, and infiltration procedures were conducted at room temperature on a Thermolyne RotoMix, Type, 48200 agitator. Samples were harvested using a razor blade, trimmed to 1 to 2-mm square dimensions, and fixed in FAA for 24 hours. Tissue was dried through a dehydration series of 85%, 95%, 100%, and 100% ethanol, each step requiring 15 to 20 minutes. Dehydration was followed by two consecutive 24-hour infiltrations with 1:1 ethanol/LR White embedding medium and 100% LR White, respectively. Each sample was then placed in a separate 1.5 ml polypropylene microcentrifuge tube containing fresh LR White embedding medium. Tubes were filled and capped to exclude air from the system, and allowed to polymerize for at least 24 hours at 60°C. During this period each sample, by sedimentation, came to occupy a position near the narrower, bottom part of the tubes. The tubes were then removed from the oven, allowed to cool, and cut from the hardened plastic pillars within. Pillars were inverted and mounted on a LKB Rotary-One retracting microtome fitted with a moat-bearing glass blade. One-micron thin sections were cut from the sample embedded in the tip of each pillar. Thin sections, when cut from the pillar, floated on the surface of the water in the moat, where they were harvested and transferred to water droplets on a glass slide using a fine-gauge tungsten needle. The slides were placed on a slide-warmer maintained at 68°C until thoroughly dry. Sections were stained with rose bengal (0.5% rose bengal dissolved in 5% aqueous ethyl alcohol) for 20 seconds, double rinsed (tap water followed by distilled water) to remove all excess stain then dried, and stained with toluidine blue (1% aqueous) for 20 seconds, double rinsed as above, and dried. The dried slides were cooled and cover-slips mounted over the sections with Permount (Fisher Scientific). Slides were subsequently examined using brightfield optics.

Mature seeds were harvested from healthy plants and from escaping culms of infected plants. They were subsequently examined for the presence of endophytic hyphae using the method of Clark et al. (1983).

RESULTS

FIELD OBSERVATIONS

At the collecting site, plants of *Aristida purpurascens*, even within close proximity to one another, displayed differing growth habits. Some were found to be robust, exhibiting rapid growth rates, frequently attaining heights over 500 cm, consistently maturing seed, and senescing shortly thereafter. Others were to varying degrees stunted, rarely flowering and never maturing seed, but exhibiting enhanced tillering rates. Such plants formed culms that produced stunted leaves, and usually bore at least one stroma, always immediately below a node. Plants of the former group never bore stromata.

POT CULTURE STUDIES

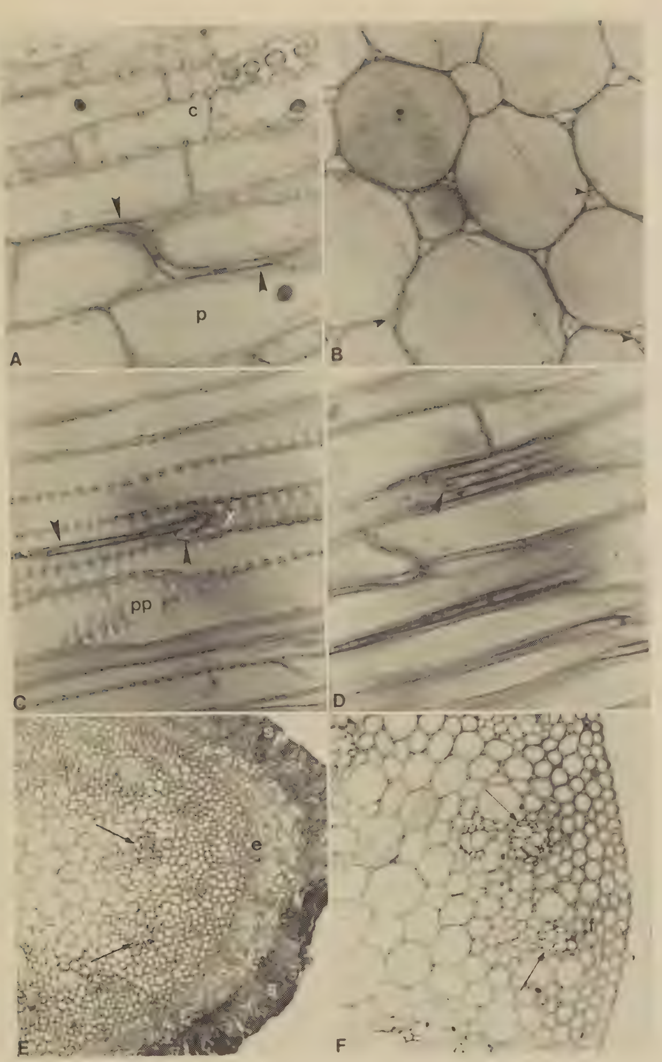
In pot culture similar differences among transplants persisted. Rarely, stunted plants were observed to produce seemingly healthy, flowering culms. Uninfected plants, however, remained unchanged, even when grown in close proximity in the same pot with stunted, stromata-bearing plants. Overwintering crowns of stunted plants produced similar, stroma-bearing plants in the spring. Neither seeds from escaping culms of these plants, nor from healthy, uninfected plants bore any fungal hyphae.

Uninfected plants grown in pots under optimal growth conditions showed slightly increased growth rates, tillering, and seed production. Stunted, infected plants, likewise, showed similar increases, including flowering occurrence. Mature seed, however, was never produced in the stunted plants. The most striking contrast between stunted plants grown under natural conditions and those grown in the growth chamber involved location and number of stromata on each culm. Under natural conditions stunted culms frequently failed to develop even a single stroma. When a stroma did develop, the node at which it egressed varied widely. Although two successive stromata occasionally occurred on a single culm, one stroma, if any, per culm was typical. Under enhanced growth conditions in the growth chamber, the first stroma was consistently produced at the second node from the base of each culm. Initial egress of the mycelium at this site occurred while the apical meristem was still just a few millimeters above the node. Rarely did stunted culms fail to develop stromata. Furthermore, culms bearing two, or even three stromata at successive nodes were not uncommon. Compared to their naturally grown counterparts, culms produced in the growth chamber were more robust, and the stromata they bore were larger and produced more perithecia.

MICROSCOPIC OBSERVATIONS

Examination of culm and leaf sections of infected, pot grown plants indicated hyphae to be present in both, although far fewer and less extensive in the leaves. With growth and maturation of the culm, progressive hyphal proliferation occurs in various tissues, leading to substantial mycelial biomass build-up prior to egress to form stromata. In young tillers, hyphae are few in number. As culms develop, hyphae occupy intercellular spaces of the pith (Plate 1, B) and are also located among phloem cap fibers peripheral to the phloem (Plate 1, F). At the time of hyphal egress to initiate primary stroma

PLATE 1. Portions of thin sections showing hyphae (indicated by arrowheads) of *Balansia aristidae* in tissues of *Aristida purpurascens*. A, mesophyll of a leaf blade in longitudinal section showing a septate hypha among parenchyma (p) and nearby chlorenchyma (c) cells [X 1500]; B-D, culm tissue prior to stroma development; B, pith in cross section showing hypha in schizogenous intercellular spaces; C, xylem in longitudinal section showing a septate hypha closely associated with one vessel (x) and a perforation plate (pp) inbetween two others; D, portion of longitudinal section showing three septate hyphae growing parallel in one intercellular space [B, X 2000; C & D X 1500]; E, portion of cross section showing ephelidial stroma (s) above intact epidermis (e) and numerous hyphae interspersed throughout ground tissue (all cell constituents other than vascular tissue) and vascular bundles (indicated by arrows) [X 300]; F, portion of cross section showing hyphae concentrated among fibers (f) and around vascular bundles (indicated by arrows) [X 1000].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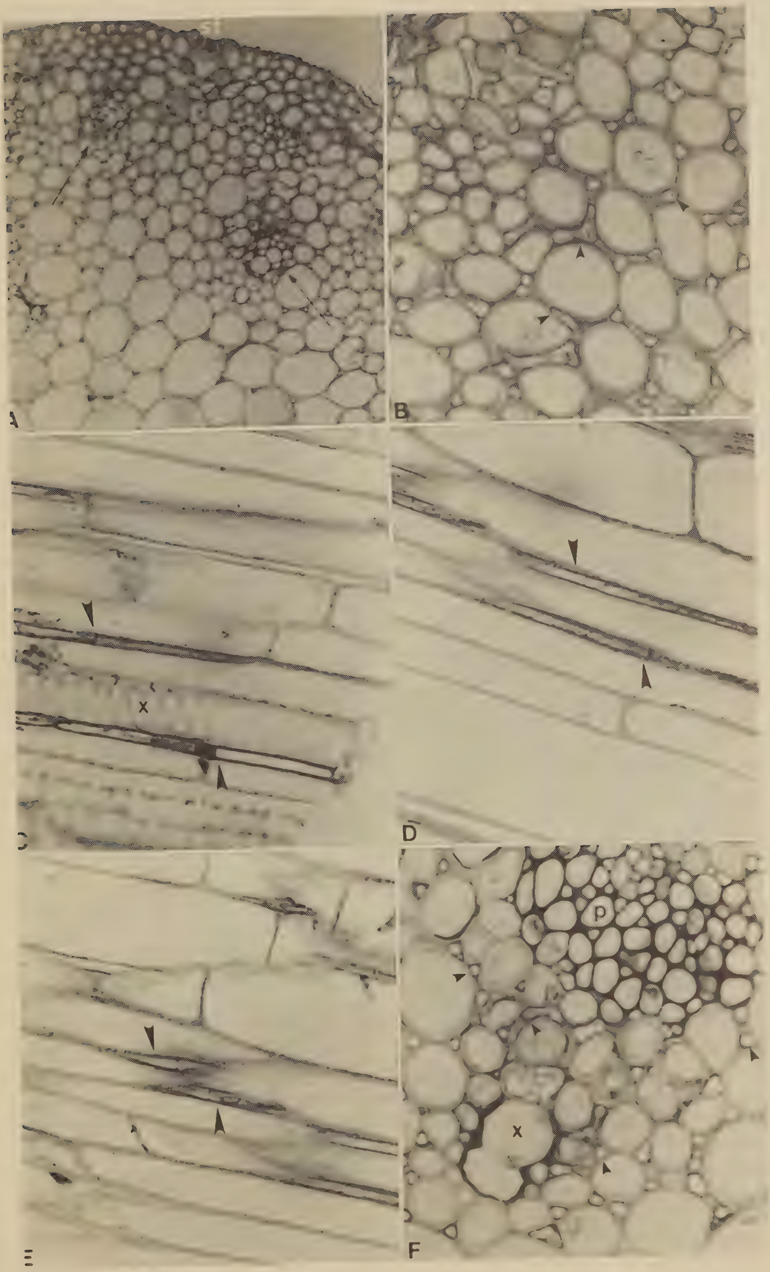
development a few hyphae are present adjacent to xylem vessels (Plate 1, C) and only rarely in the phloem. Eventually, hyphal proliferation in the culm increases significantly near the site of egress and stroma formation. At the stage of development when primary, *Ephelis* stromata are formed, hyphae are abundant throughout culm tissues, even within and around vascular bundles (Plate 2, C & F). Host cells, especially phloem cap fibers, frequently become surrounded by multiple hyphae growing parallel to them and may be separated by hyphae growing laterally (Plate 2, B).

At a later stage when perithecial initiation occurs, cells of the culm tissue proximal to the stroma become almost totally surrounded by hyphae growing in all directions. In the pith, one to several hyphae may be present in each intercellular space (Plate 3, A-C). Hyphal buildup continues until perithecial maturation at which time many host cells, particularly phloem fibers, become completely isolated at certain points from adjacent cells by intervening hyphae (Plate 3, D). Even at this highly intrusive and disruptive stage of hyphal development, host cells nevertheless appeared healthy and functional. Hyphal growth was not as intrusive within the vascular bundle among conductive cells of the phloem and xylem, but it did extend between companion and parenchyma cells at the periphery (Plate 3, E). No degradation of host cell walls was evident. Hyphae were absent in young leaves, but present toward the base of well-developed leaves. Hyphal growth within the leaf was longitudinal for the most part (Plate 1, A). Though scattered in leaf tissue, hyphae occurred mostly in and around vascular tissue, especially of the mid vein.

DISCUSSION

There is little doubt from the observations made of individual plants, and from examination of sections, that hyphae of *Balansia aristidae* are vegetatively, endogenously transmitted in successive tillers from year to year. Once a plant is infected, the fungus perennates in the host tissue from season to season, over-wintering in the dormant crown of the plant. When normal culm elongation and inflorescence development sometimes occur in plants known to be infected it seems reasonable to assume that rapidly growing shoots can, on occasion, outrun the pathogen depending upon prevailing nutritional and climatic conditions. Daughter plantlets arising from tillers by vegetative propagation can carry the fungus, thus effectively giving rise to a plurality of infected plants.

PLATE 2. Portions of thin sections showing hyphae (indicated by arrowheads) of *Balansia aristidae* in *Aristida purpurascens* culms bearing ephelidial stromata. A, portion of cross section showing hyphae throughout ground tissue and vascular bundles (indicated by arrows), as well as a stomate (st) among epidermal cells [X 1000]; B, portion of cross section showing hyphae growing longitudinally and laterally in tissue [X 1500]; C, xylem in longitudinal section showing septate hyphae associated with vessels (x) and parenchyma cells [X 1500]; D & E, ground tissue in longitudinal section showing septate hyphae inbetween cells [X 1500]; F, vascular bundle in cross section showing hyphae in phloem (p) and xylem (x) [X 1500].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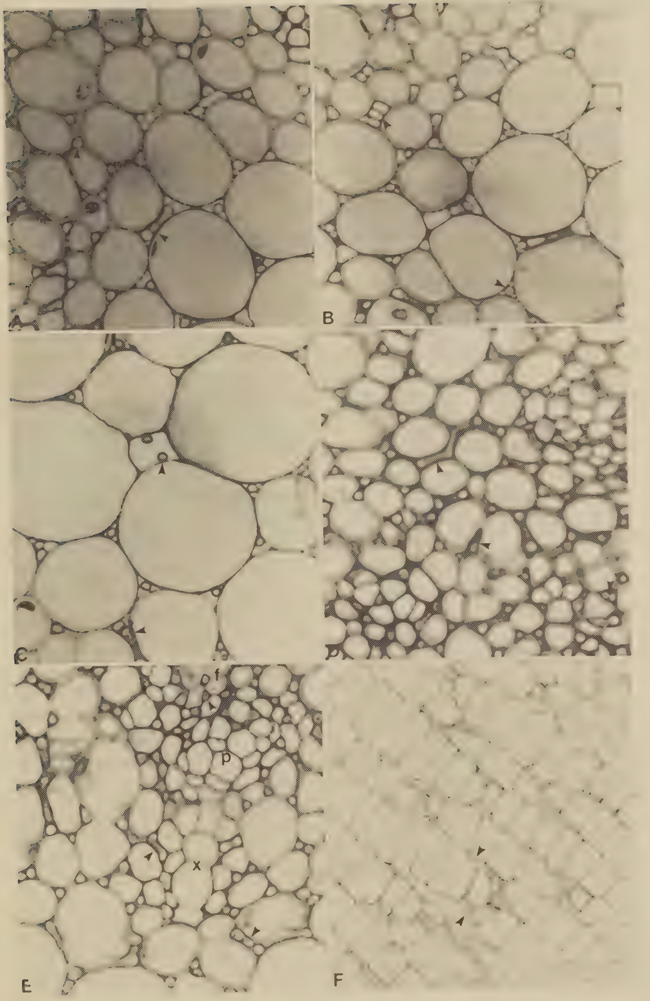
This may be the only way by which new infected plants come into existence since no fungal hyphae have been found in seed, even when produced on plants harboring the fungus. As in the case of many other members of the Balansieae, it is not known if horizontal transmission of the fungus from plant to plant by *Ephelis* macroconidia and/or ascospores occurs and if so with what frequency and under what conditions. At the site of collection, very few stroma-bearing plants were encountered among a large stand of *Aristida purpurascens*. Likewise, in pots maintained outdoors, uninfected plants remained in that condition for over two years when grown in close proximity in the same pot with infected, stroma-bearing plants.

Attempts to determine if infection by conidia and/or ascospores occurs in various Balansieae, and the site of entry into host plants, have largely been inconclusive. A number of techniques were employed by Diehl (1950) including misting spore suspensions onto surfaces of leaves, culms and inflorescences, injecting conidia and mycelium into culms, and brushing conidia onto stigmas. Little success was achieved; however, in one experiment, three plants of *Cenchrum echinatus* L. grown from seeds originating from plants whose stigmas had been inoculated with *Balansia obtecta* Diehl conidia bore stromata. This led Diehl (1950) to consider the most likely infection route of a number of Balansieae to be via host stigmas.

In other experiments Western and Cavett (1959) reported being able to infect plants of *Dactylis glomerata* L. with *Epichloe typhina* only by applying conidia and ascospores to cut ends of stubble while Muhle and Frauenstein (1970) succeeded in infecting *Phleum pratense* L. with the same fungus by inoculating seedlings with mycelium in aseptic culture. Rykard *et al.* (1985) failed to infect hosts of *Balansia epichloe* and *Myriogenospora atramentosa* by a variety of methods, including some similar to those of Diehl. Leuchtmann and Clay (1988) artificially infected the respective hosts of *Atkinsonella hypoxylon* and *A. texensis* with the fungi by inserting mycelium and conidia with a needle above the meristem of seedlings grown in aseptic culture. *Cyperus virens* Michx. was infected with *Balansia cyperi* by the same procedure. In nature, it seems likely that infection by spores, whether they be conidia or ascospores, can only occur under certain critical environmental conditions, particularly if entry is gained through leaves. Clearly there is much yet to be learned about modes of natural infections.

PLATE 3. Portions of thin sections showing hyphae (indicated by arrowheads) of *Balansia aristidae* in tissues of *Aristida purpurascens*. A-C, tissue from culms bearing mature ephelidial stromata; A & B, portions of cross sections showing hyphae growing longitudinally and laterally in tissue, including fibers, pith, and xylem, often several per intercellular space [X 1500]; C, pith in cross section showing hypha in schizogenous intercellular spaces [X 2000]; D-F, tissue from culms bearing perithecial stromata; D, portion of cross section showing hyphae growing longitudinally and laterally in tissue, often nearly isolating individual cells [X 1500]; E, vascular bundle in cross section showing distribution of hyphae relative to phloem (p) and xylem (x) elements, fibers (f), and throughout surrounding tissue [X 1500]; F, ground tissue in oblique section showing hyphae in intercellular spaces [X 1500].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Infection of grasses by species of the Balansieae, as noted in the introduction, brings about changes in host plant growth and reproductive capacity. The observations reported herein on the effects of *B. aristidae* on *Aristida purpurascens* are no exception. Quite clearly the energy loss to the plant as a result of endophytic hyphal biomass build-up is substantial and often results in sterility. Although there are no overt external symptoms of infection prior to egress and no apparent physical disruption of the integrity of individual plant cells, energy depletion invariably results in stunting.

Nutritional requirements for growth of the extensive endophytic mycelium and for external stromata development, at least initially, in *Balansia aristidae* are assumed to be predominantly satisfied by intercellular carbohydrate sources. Sucrose, the predominant soluble form in which carbohydrates are transported in plants, is present in the apoplast in low concentrations (Thrower and Lewis, 1973). In early systemic spread through culms, hyphae are rather sparse but later development may be dependent upon additional sources of energy. Although no evidence of any host cell wall degradation was found during the course of this study, it seems possible that some change in host cell wall permeability might be brought about. Of the total endophytic fungal biomass formed, a substantial portion, even during early stages of proliferation in culm tissue, occurs among phloem cap fibers and eventually in vascular tissue generally. Proximity to the conductive cells of the host probably enhances availability of sucrose. The relationship of the intercellular systemic mycelium of *B. aristidae* with its host appears to be similar to that documented by Thrower and Lewis (1973) between *Epichloe typhina* and *Agrostis stolonifera* (Fr.) L. although there are some differences, particularly the fact that mycelium of *E. typhina* may become intracellular. Samson (1933) and Thrower and Lewis (1973) demonstrated close association between that fungus and the vascular system of its hosts. The latter authors showed sucrose to be the principal sugar acquired, with an accompanying transformation to mannitol and trehalose by the fungus. Hyphal growth in schizogenous intercellular spaces of the pith, although unimpeded, is generally sparser probably due to low levels of nutrients. With progressive disruption of host tissue, as fungal hyphae intrude between individual cells, the middle lamella is affected and its breakdown, particularly that of the substantial layer associated with phloem fibers, may provide another source of sugar. More studies are needed before pathogen nutrient acquisition is fully understood.

ACKNOWLEDGMENTS

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KRETZSCHMARIA, LEPRIEURIA, AND PORONIA IN MEXICO

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ABSTRACT

Eight species of *Kretzschmaria* and single species of *Leprieuria* and *Poronia* are described from Mexico. Anamorphs of *K. heliscus* and an unnamed species allied to *K. heliscus* are described from culture.

Key words: *Kretzschmaria, Leprieuria, Poronia*, pyrenomycetes, Xylariaceae

In 1989 San Martín and Rogers published a preliminary account of *Xylaria* Hill ex Schrank in Mexico. In 1993 we published an account of *Biscogniauxia* and *Camillea* in Mexico (San Martín and Rogers, 1993). In the present paper we discuss Mexican taxa of *Kretzschmaria, Leprieuria*, and *Poronia*. Data were given on materials and methods and collecting sites in San Martín and Rogers (1993); the reader is referred to that paper for such relevant data.

Kretzschmaria Fr.

Kretzschmaria includes mostly taxa with more or less flat-topped fertile stromata, borne upon short to almost obsolete stipes, that are often densely cespitose and, indeed, sometimes resemble a continuous crust. As far as is known, anamorphs are borne in palisades on immature stromata as in many species of *Xylaria*. Stromata of most species have a white interior at first, becoming hollow as the interior tissue disintegrates. Mature forms of most taxa show perithecia beneath a hard to extremely hard, thin outer crust. In this respect, *Kretzschmaria* greatly resembles *Ustulina* Tul. & C. Tul. into which it intergrades in the tropics and, indeed, Martin (1970) placed the latter genus into synonymy with the former. We will treat *Ustulina* elsewhere. Asci have an amyloid (bluing in Melzer's iodine reagent) apical ring. Mature ascospores are brown to nearly black with a germ slit.

Our general concept of *Kretzschmaria* is that of Dennis (1957) who, in turn, accepted the general concept of Lloyd (1919). The relationship of *Kretzschmaria* with certain *Xylaria* spp. is undoubted and, in the future, the genera might be merged. For the present, however, it is most convenient to treat them as separate.

KEY TO SPECIES OF KRETZSCHMARIA FROM MEXICO

1. Ascospores up to 11 μm long 2

1. Ascospores longer than 11 μm 3

    2. Fertile parts subglobose, with flattened and somewhat verrucose upper part, on short to long stipes, the whole 4-7 mm high x 1-2 mm broad. Ostioles papillate-hemispherical, occasionally surrounded by a disc 0.07-0.1 mm diam. Ascospores (8-)8.5-10(-11) x 4.5-5(-5.5) μm . . . . *Kretzschmaria heliscus*

    2. Fertile parts subglobose, with upper part verrucose, on short, hirsute stipes, 1-4.5 mm high x 2-2.5 mm broad. Ostioles obscure to papillate-hemispherical. Ascospores 9-10 x (3.5-)4(-4.5) μm . . . . *Kretzschmaria* sp. aff. *heliscus*

3. Ascospores longer than 26 μm 4

3. Ascospores not longer than 26 μm 7

    4. Fertile parts globose to subglobose, 0.8-1.2 mm high x 1.5-5 mm broad, with surface slightly to conspicuously verrucose, arising from flattened, prostrate, profusely ramified stipes. Ostioles discreet, conic-papillate. Ascospores (29-)30-41(-42) x 8-11(-12) μm . . . . *Kretzschmaria* sp. aff. *cetrarioides*

    4. Fertile parts arising from upright stipes 5

5. Fertile parts subglobose, 5-6 mm high x 2-4.5 mm broad, usually enclosing one perithecium. Ostioles prominent, conic-papillate. Ascospores (30-)31-35(-36) x (9-)10-12(-12.5) μm . . . . *Kretzschmaria micropus*

5. Fertile parts enclosing more than one perithecium 6

    6. Fertile parts sessile and pulvinate or stipitate and subglobose, 0.5-2 cm high x 0.2-2.5 cm broad. Ostioles papillate, somewhat hemispherical. Ascospores (26-)28-35(-36) x 7-8(-9) μm . . . . *Kretzschmaria* cf. *bulgarioides*

6. Fertile parts subglobose, sessile or stipitate, 0.5-3.4 cm high x 1-7 mm broad. Ostioles obscure to discreetly papillate-conical. Ascospores (23.5-)24-35 x 6-8(-8.5) µm .... *Kretzschmaria clavus sensu lato*

7. Fertile parts peltate, subsessile or short-stipitate, 3-4 mm high x 4-9 mm broad. Ostioles prominently papillate-hemispherical. Ascospores (18-)19-21.5(-22) x 7-8 µm, with sigmoid to spiral germ slit .... *Kretzschmaria* cf. *mauritanica*

7. Fertile parts globose to subglobose, sessile or short-stipitate, 1-4.5 mm high x 1-2.5 mm broad. Ostioles obscure to conic-papillate. Ascospores 19-24(-26) x 6-8(-9) µm, with straight germ slit and frequently with a minute hyaline, cellular appendage at one end .... *Kretzschmaria* sp. (San Martín 930).

Kretzschmaria cf. *bulgarioides* Rehm, Hedwigia 40:143. 1901.

Stromata sessile and pulvinate, or subglobose on smooth stipes, with upper part somewhat convex and umbonate, the whole 0.5-2 cm high x 0.2-2.5 cm broad; externally brown to dark-brown, internally black, partially hollow. Texture hard but fragile, carbonous. Surface smooth at the top, cracked on the sides. *Perithecia* 0.7-1 mm diam. Ostioles papillate, somewhat hemispherical. *Asci* cylindrical, eight-spored, with spore arrangement uniseriate to partly biseriate, long-stipitate, 264-338 µm total length x 7-8(-9) µm broad, the spore-bearing part 184-223 µm, with apical ring bluing in Melzer's iodine reagent, urn-shaped to rectangular, 7-8 µm high x 4-5 µm broad. *Ascospores* dark-brown, ellipsoid-inequilateral to crescentic, with narrow to pinched ends, (26-)28-35(-36) x 7-8(-9) µm, with straight germ slit less than spore-length on flattened side.

SPECIMENS EXAMINED: Nuevo León state, Santiago municipality, El Cercado, 25.VII.87, Moreno 201, on rotten wood in submontane scrub with *Quercus* spp. (ITCV;JDR); IX.87, San Martín 363, on *Quercus* sp. stump in submontane scrub with *Quercus* spp. (ITCV;JDR); 23.X.88, San Martín 1148, on wood of *Quercus ryzophylla* Weath. in submontane scrub with *Quercus* spp. (ITCV;JDR).

ADDITIONAL SPECIMEN EXAMINED: *Kretzschmaria bulgarioides* Rehm; Brazil, Ule (S;TYPE).

NOTES: This curious collection fits well the description of Rehm (1901) of *Kretzschmaria bulgarioides*. It is remarkable by the presence in the same stromatal complex of both sessile and stipitate areas. The sessile forms strongly resemble *Ustulina deusta* (Hoffm.:Fr.) Petrak but with somewhat narrow ascospores as compared with collections obtained from southern states of México (see description of *Ustulina deusta* in Miller, 1961, as *Hypoxylon deustum*). It is much like type material, but ascospores of type material are (35-)36-40(-41) x (7-)7.5-9(-10) µm.

Kretzschmaria clavus (Fr.) Sacc., Syll. Fung. 2, p. XXIX. 1883. *Sensu lato.*

The teleomorph is much as described by Dennis (1957). *Asci* cylindrical, eight-spored, with obliquely uniseriate spore arrangement, short-stipitate, 205-283 μm total length x 7-10 μm broad, the spore-bearing part 147-214 μm, with apical ring bluing in Melzer's iodine reagent urn-shaped, 5-6 μm high x 4-4.5(-5) μm broad. *Ascospores* brown, ellipsoid-inequilateral with narrowly-rounded to somewhat pinched ends, (23.5-)24-35 x 6-8(-8.5) μm, with straight germ slit less than spore-length on flattened side.

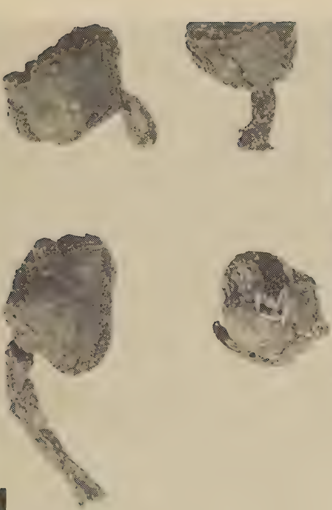
SPECIMENS EXAMINED: Oaxaca state, Temazcal town, 8.X.88, San Martín 1101, on wood in median subdeciduous tropical rain forest (ITCV;JDR). Chiapas state, Mapastepec municipality, El triunfo-Paval hike road, 9.VI.88, San Martín 738, on dicot wood in cloud jungle (ITCV;JDR); Ocosingo municipality, Ejido Boca de Chajul, 27.VIII.87, San Martín 326, 382, 388 & 550, on wood in evergreen tropical rain forest (ITCV;JDR); Ejido Loma Bonita, 22.VIII.87, San Martín 482, on wood in evergreen tropical rain forest (ITCV;JDR); "El Muñeco", VIII.87, San Martín 358, on wood in evergreen tropical rain forest (ITCV;JDR); Montes Azules Biosphere Reserve, 27.V.88, San Martín 802, 809 & 819; 30.V.88, San Martín 758, (same data as San Martín 326 above).

NOTES: Collection San Martín 758 is a tall form of *K. clavus* with stipes 1.5-2.7 cm high, fertile heads 1-7 mm broad, and ascospores longer than the other collections, i.e., 28-35 μm vs 24-31.5 μm. It is much like *K. botrites* Lloyd as depicted by Lloyd (1920).

Collections San Martín 382, 388, 738, 802 & 819 are herein considered to be *K. clavus* with some hesitation. Stromata are constantly sessile or with stipes no more than 3 mm high, the surface of the fertile part is verrucose and the upper part usually shows an umbo. Although the ascospores have the same size range as those of *K. clavus*, they have narrow ends instead of broadly rounded ones. Rehm (1901) described from Brazil a *Kretzschmaria* as *K. ?coenopus* with characteristics that fit those of the collections mentioned above. Such collections are considered to be *K. clavus* until examination of material of *K. ?coenopus* is done and comparative studies of anamorphs of typical *K. clavus* and the sessile collections are accomplished. A fungus similar to the Mexican one was reported from British Guiana by Dennis (1970), as *K. lucidula* (Mont.) Dennis, but with larger ascospores, i.e., 34-40 x 9-12.5 μm vs the range given above.

Kretzschmaria heliscus (Mont.) Massee, Kew Bull. 1898:118. 1898.

Figs. 1-6. *Kretzschmaria* sp. (San Martín 930) and *Kretzschmaria* sp. aff. *heliscus* 1, 2. *Kretzschmaria* sp. (San Martín 930). 1. Stromata, X 10. 2. Stromatal surface, X 23. 3-6. *Kretzschmaria* sp. aff. *heliscus*. 3. Stromata, X 1.4. 4. Stromata, X 12. 5. Stromatal surface, X 16. 6. Culture, X 0.6.



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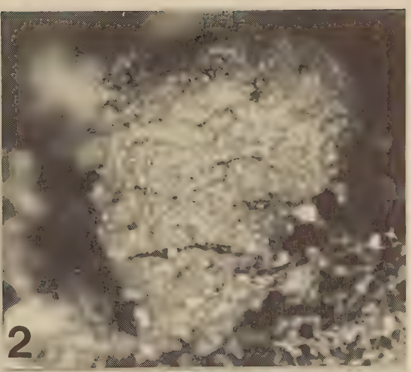

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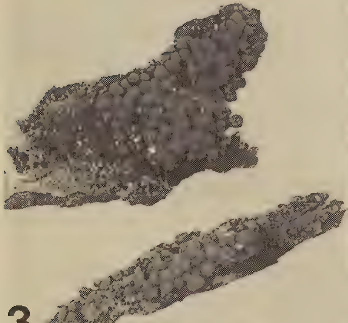

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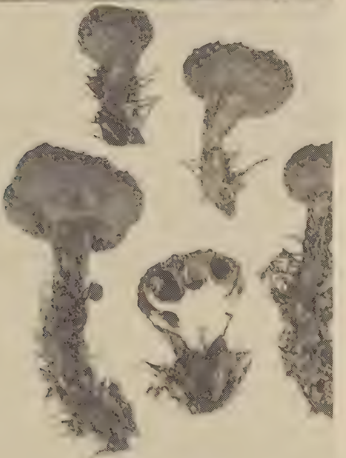

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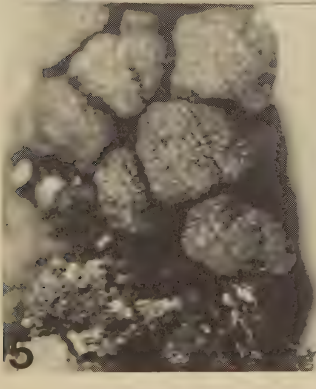

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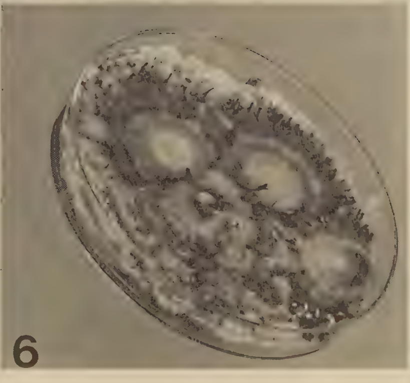

6

The teleomorph is as described by Dennis (1957) and Rogers *et al.* (1987). *Colonies* covering 9 cm Petri plate in 11 days, at first whitish, appressed, with plumose margins, then grayish and furrowed, farinose, overlain by blackish, more or less floccose, mycelium radiated from the center towards the edges. Reverse unchanged. *Stromata* clavate, branched from the base, with globose heads, produced in the periphery, 3-5 mm high x 0.5-0.8 mm broad, white with greenish tips. Conidium-bearing regions on the upper surfaces of the stromata. *Conidiophores* in upright dense palisades, sparingly ramified, hyaline, smooth. *Conidiogenous cells* cylindrical, 17-30 x 4-5 μm, hyaline to pale olivaceous-brown, bearing prominent lateral and terminal denticulate secession scars. Conidia produced holoblastically in sympodial sequence. *Conidia* hyaline to pale-olive (greenish in mass), lacrymoid to ellipsoid, (6-)6.5-7(-8) x 4.5-5 μm, with flattened bases indicating former points of attachment to conidiogenous cell.

SPECIMEN EXAMINED: Veracruz state, Catemaco municipality, Los Tuxtlas UNAM Biological Station, 4.XI.88, San Martín 1247 (CULTURED), on dicot wood in evergreen tropical rain forest (ITCV;JDR).

ADDITIONAL SPECIMEN EXAMINED: *Kretzschmaria scruposa* Pat.; New Caledonia, Yahoue, 1903 (FH;TYPE).

NOTES: This fungus fits typical *K. heliscus* as described by Dennis (1957) and Rogers *et al.* (1987). *Kretzschmaria scruposa* Pat., considered by Dennis (1957) to be a synonym of *K. heliscus*, has larger ascospores, i.e., 11-13(-14.5) x 5-6 μm vs (8-)8.5-10(-11) x 4.5-5(-5.5) μm. *K. scruposa* might be a large-spored variant of *K. heliscus*.

Kretzschmaria cf. *mauritanica* (Dur. & Mont.) Pat., Bull. Soc. Mycol. France. 21:120. 1905. Figs. 7-9.

Mexican material is much as described by Rogers *et al.* (1987) except for the absence of whitish outer peeling layer, presence of hemispherical ostioles and shorter ascus stalks.

SPECIMENS EXAMINED: Chiapas state, Jaltenango municipality, El Triunfo Hill, 8.VI.88, San Martín 661 & 673, on dicot wood in cloud jungle (ITCV;JDR).

ADDITIONAL SPECIMEN EXAMINED: *Kretzschmaria mauritanica* (Dur. & Mont.) Pat.; Algero-Tunisiens (FH;TYPE).

NOTES: Miller (1961) considered *K. mauritanica* to be a *Penzigia*. This fungus has the ascospore morphology of the *Xylaria polymorpha* complex. Indeed, the shape, size, and type of germ slit are the same as encountered in *X. scruposa* [see San Martín and Rogers (1989) for description of *X. scruposa*]. Perhaps, it is a peltate form of *X. scruposa* with short stipes and smoother surface.

Type material is fragmentary and somewhat immature. Ascospores are 17-22 x 6-7.5 μm with short, straight to sigmoid germ slits.

Kretzschmaria micropus (Fr.) Sacc., Syll. Fung. 2, p. XXIX. 1883.

Teleomorph is much like that described by Miller (1942) and Dennis (1957). *Ascospores* brown to dark-brown, ellipsoid-inequilateral to navicular with rounded to narrow ends, (30-)31-35(-36) x (9-)10-12(-12.5) μm, with straight germ slit slightly less than spore-length on flattened side.

SPECIMEN EXAMINED: Oaxaca state, Temazcal town, 8.X.88, San Martín 1125, on dicot wood in median subevergreen tropical rain forest (ITCV;JDR).

ADDITIONAL SPECIMEN EXAMINED: *Kretzschmaria spinifera* Ellis & Mcb.; México, 1895, C. L. Smith *s.n.*, (NY;SYNTYPE).

NOTE: The Mexican collection fits the concept of Miller (1942) and Dennis (1957) of *Kretzschmaria micropus*. Packages with the type of *K. spinifera* Ellis and Macb. at NY contain two sessile fungi: one of them fits Miller's (1961) concept of *Hypoxylon cyclopicum* Speg., having ascospores 33-40 x 11-13.5 μm with straight germ slit; the other, considered herein the type of *K. spinifera*, is smaller and has ascospores (40-)41.5-50(-53) x (12.5-)13-14(-15) μm with sigmoid to spiralling germ slit. *Kretzschmaria spinifera* was considered a synonym of *K. micropus* by Dennis (1957). Neither of the fungi in the packages containing *K. spinifera* at NY resemble the stipitate *K. micropus* as depicted by Dennis (1957). *Kretzschmaria spinifera* was collected by C. L. Smith in an unknown locality of México in 1895.

This peculiar fungus often appears to have multiple ostioles for single perithecia. In reality these apparent ostiolar projections are probably the remains of coremia associated with the developing stroma.

Kretzschmaria sp. aff. *cetrarioides* (Welw. & Curr.) Sacc., Syll. Fung. 2, p. XXIX. 1883.

Stromata consisting of closely aggregated, globose to subglobose, fertile heads, 0.8-1.2 mm high x 1.5-5 mm broad, on flattened, prostrate, smooth, profusely ramified stipes, ca. 5 cm long; externally brown to dark-brown, internally at first white, fleshy, then blackish-white. Texture hard and carbonous. Surface slightly to conspicuously verrucose. *Perithecia* 3-20 per fertile head, subglobose, 0.4-1 mm broad. Ostioles conic-papillate, discrete. *Asci* cylindrical, eight-spored, exceptionally four-spored, with uniseriate to obliquely-uniseriate spore arrangement, short-stipitate, 256-298 μm total length x 11.5-12(-13) μm broad, the spore-bearing part 173-233 μm, with apical ring bluing in Melzer's iodine reagent, urn-shaped, 8-12(-13) μm high x (5.5-)6-7 μm broad. *Ascospores* brown to dark-brown, ellipsoid-inequilateral to navicular with rounded ends, (29-)30-41(-42) x 8-11(-12) μm, with straight germ slit slightly less than spore-length on flattened side.

SPECIMENS EXAMINED: Quintana Roo state, José María Morelos municipality, I.86, Gonzalo Guevara 719, on wood in an acahual (ITCV;JDR). Tamaulipas state, Gómez Farías town, 14.IX.88, San Martín 1110C, on wood of *Brosimum alicastrum* Sw., ("ojite") in median subdeciduous tropical rain forest

(ITCV;JDR); Ocampo municipality, X.87, Lucrecia García 20 & 28, on *Quercus* wood in submontane scrub with *Quercus* spp. (ITCV;JDR).

ADDITIONAL SPECIMENS EXAMINED: *Kretzschmaria novoguineensis* Henn.; New Guinea, (HBG;AUTHENTIC). *Kretzschmaria pechuelii* Henn.; Angola, (HBG;AUTHENTIC).

NOTES: Collections Lucrecia García 20 & 28 and San Martín 1110C, are close to *Kretzschmaria cetrarioides*, but differ from it in having larger ascus rings and ascospores. In size of the ascospores, those collections also resemble *K. coenopus* (Fr.) Sacc., but the manner in which the fertile heads arise from the stipes, and the verrucose surface are not typical of that species. Perhaps they are a variety of *K. cetrarioides*.

Collection Guevara 719 shares the same shape and spore size as the collections mentioned above, but its surface is smoother. The latter character is found in *K. pechuelii* Henn., a fungus listed by Dennis (1957) as a synonym of *K. cetrarioides*, but its ascospores are smaller.

Kretzschmaria sp. aff. *heliscus* (Mont.) Massee, Kew. Bull. 1898:118. 1898.
Figs. 3-6, 13-17.

Stromata densely aggregated, unbranched to branched 2-3 times above stipes, subglobose, on short, hirsute stipes arising from a shiny-brown, woolly subiculum, 1-4.5 mm total length x 2-2.5 mm broad; externally dark-brown to black, internally white, fleshy. Texture hard but fragile, somewhat carbonous. Surface verrucose with cracking and polygonal plaques. *Perithecia* 0.3-0.4 mm broad. Ostioles obscure to papillate-hemispherical. *Asci* cylindrical, eight-spored, with obliquely uniseriate spore arrangement, long-stipitate, 111.5-132 μm total length x 5-6(-6.5) μm broad, the spore-bearing part 56-61 μm, with apical ring bluing in Melzer's iodine reagent, cubical to rectangular, 2-3 μm high x 2-2.5 μm broad. *Ascospores* light-brown to brown, ellipsoid-inequilateral to navicular with narrow ends, 9-10 x (3.5-)4(-4.5) μm, with straight germ slit spore-length on flattened side.

Figs. 7-17. *Kretzschmaria* cf. *mauritanica*, *Kretzschmaria* sp. (San Martín 930), and *Kretzschmaria* sp. aff. *heliscus*. 7-9. *Kretzschmaria* cf. *mauritanica*. 7, 8. Ascospores, that in Fig. 8 showing faint germ slit, X 1500. 9. Ascus apical ring, X 1500. 10-12. *Kretzschmaria* sp. (San Martín 930). 10, 11. Ascospores, X 1500. 12. Ascus apical ring, X 1500. 13-17. *Kretzschmaria* sp. aff. *heliscus*. 13, 14. Ascospores, that in Fig. 14 showing ventral germ slit, X 1750. 15. Ascus apical ring, X 2200. 16. Conidiogenous hymenium. One conidium pointed out with arrow, X 1650. 17. Conidia, X 1650.

Figs. 7-15 by brightfield microscopy. Figs. 16, 17 by differential interference contrast microscopy; Figs. 9, 12, 15 from mounts in Melzer's reagents. Other figs. from water mounts.

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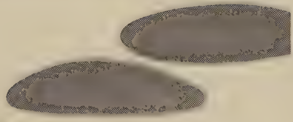
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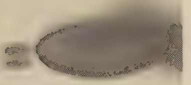
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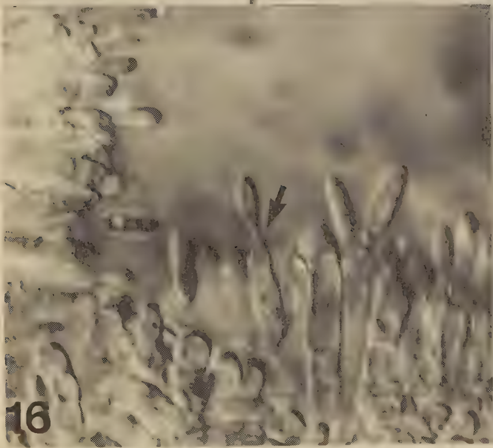
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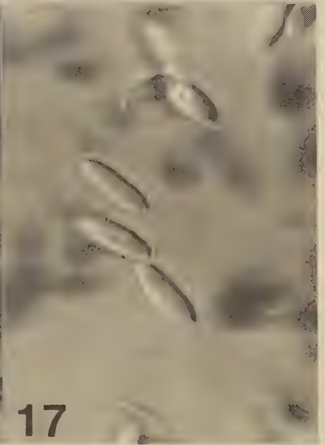
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Colonies covering Petri plate in 3 wk, at first white, then producing white and greenish-dark concentric zones, cottony, with appressed, somewhat dentate margins. Reverse at first slightly brown, then brown. *Stromata* acicular to somewhat palmate, unbranched to branched, produced in a concentric fashion, 1.5-3 mm high x 0.6-0.7 mm broad, black and tomentose at bases with whitish-cream tips. Conidium-bearing regions produced as small, white-cream, stromatal heads. *Conidiophores* in upright dense palisades, di- or trichotomously branched, hyaline to somewhat brownish, smooth. *Conidiogenous cells* cylindrical, hyaline, 17-31 x 2-3 μm, bearing terminal and lateral poroid conidial secession scars. Conidia produced holoblastically in sympodial sequence. *Conidia* hyaline, ellipsoid to somewhat fusiform, 5.5-8.5(-9) x 2-3 μm, with one end truncate indicating former points of attachment to conidiogenous cell.

SPECIMENS EXAMINED: Campeche state, Escárcega municipality, Ing. Eduardo Sangri Serrano Forestry Experimental Station, 9.XI.88, San Martín 1498 (CULTURED), on wood of *Achras zapota* L., in median subdeciduous tropical rain forest (ITCV;JDR). Tamaulipas state, Gómez Farías municipality, Ejido Julilo, 1.XI.87, Santiago Chacón 362, on wood in mixed forest of *Quercus* spp. and tropical elements (ITCV;JDR); Gómez Farías town, 24.VII.88, Guillermo Villasana 90, (CULTURED) on wood in median subdeciduous tropical rain forest (ITCV;JDR).

NOTES: This fungus is close to *Kretzschmaria heliscus* but differs in the complete absence of discs and black halos around the ostioles, in the conspicuous hairiness of the stipes, in having smaller asci and ascospores, and in producing different cultural and anamorphic characters (see description of teleomorphic stromata of *K. heliscus* in Rogers *et al.*, 1987, and characteristics of the anamorph described herein). This fungus also seems similar to *K. tuckerii* Lloyd, a fungus that apparently was never described, but was shown in photographs by Lloyd (1925, Figs. 3163 and 3164) and by Martin (1970). Type material at NY was said to lack ascospores (Martin, 1970). The Mexican fungus might well represent this or a new taxon.

Kretzschmaria sp. (San Martín 930). Figs. 1-2, 10-12.

Stromata erumpent, with globose to subglobose, solitary, sessile fertile heads, 1-2.5 mm diam, or with several similar fertile heads grouped on short, smooth stipes, the whole 1-4.5 mm high; externally at first white then yellowish to blackish, internally white, fleshy. Texture hard, carbonous. Surface somewhat verrucose. *Perithecia* 0.7-1.1 mm broad. Ostioles obscure to conic-papillate. *Asci* cylindrical, eight-spored, with uniseriate spore arrangement, stipitate, 194-270 μm total length x 9.5-12 μm broad, the spore-bearing part 117-160 μm, with apical ring bluing in Melzer's iodine reagent, rectangular, somewhat flared upward, 4 μm high x 3-3.5 μm broad. *Ascospores* brown to dark-brown, ellipsoid-inequilateral to navicular with rounded, narrow, acute or pinched ends, sometimes with a minute cellular, hyaline appendage (ca. 0.5-1 μm long x 1-2 μm broad) at one end, 19-24(-26) x 6-8(-9) μm, with straight germ slit slightly less than spore-length on flattened side.

SPECIMENS EXAMINED: Nuevo León state, Santiago municipality, El Cercado, VIII.87, San Martín 930, on dicot wood in submontane scrub with *Quercus* spp. (ITCV;JDR); 16.IV.88, Lucrecia García 20B, on wood in submontane scrub with *Quercus* spp. (ITCV;JDR). Tamaulipas state, Victoria municipality, El Madroño, 20.IV.87, San Martín 73, on wood in an oak forest (ITCV;JDR).

NOTES: This fungus apparently is restricted to oak habitats. It is reminiscent of *Hypoxylon regale* Morg., as described by Miller (1961), but the latter is consistently sessile, and its ascospores are broader and devoid of a cellular appendage at one end.

This taxon also shares some characteristics with *Penzigia quercus* E. Müller & Ahmad, a fungus said to colonize wood of *Quercus dilatatae* Lindl. in Pakistan (Müller & Ahmad, 1955), but ascospores of the latter bear a hyaline sheath, lack a cellular appendage, and are considerably longer than those of the Mexican collection, i.e., 24.5-39 x 11-16 μm vs 19-24(-26) x 6-8(-9) μm.

Leprieuria bacillum (Mont.) Laessøe, J. D. Rogers and Whalley, Mycol. Res. 93:152. 1989.

The teleomorph is as described by Dennis (1957) as *Camillea bacillum* (Mont.) Mont. The teleomorph, and the *Geniculosporium* Chesters & Greenhalgh anamorph which they obtained in culture, were described by Samuels and Müller (1980).

SPECIMENS EXAMINED: Chiapas state, Jaltenango municipality, Santa Rita-El Triunfo Hill hike trail, 7.VI.88, San Martín 628, on *Quercus* sp. wood in cloud forest (ITCV;JDR). Ocosingo municipality, Ejido Boca de Chajul, VIII.87, San Martín 346 on wood in evergreen tropical rain forest (ITCV). Oaxaca state, Temazcal town, 8.X.88, San Martín 1102, on wood in median subdeciduous tropical rain forest (ITCV;JDR). Veracruz state, Catemaco municipality, Los Tuxtlas UNAM Biological Station, 4.XI.88, San Martín 1421, on wood in evergreen tropical rain forest (ITCV;JDR).

NOTE: The Mexican collection is typical of this species of the monotypic genus.

Poronia oedipus (Mont.) Mont., Ann. Sci. Nat. Bot. (sér. 4) 3, 114. 1855.

The teleomorph is as described by Theissen (1909), Miller (1942), and Dennis (1957). Jong and Rogers (1969) described the teleomorph and anamorph in culture.

SPECIMENS EXAMINED: Tamaulipas state, Gómez Farías municipality, Ejido Alta Cima, 25.VI.88, Angeles Cortéz 1, on cow dung in cloud forest (ITCV;JDR); Mier municipality, Falcón Dam, 1987, San Martín 2001, on cow dung on semiarid spiny scrub (ITCV;JDR).

NOTE: This material is typical of *Poronia oedipus* (Mont.) Mont.

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A NUMERICAL TAXONOMIC STUDY ON THE POSITION OF MARAVALIA AND OTHER GENERA OF UREDINALES

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ABSTRACT

A numerical taxonomic analysis (UPGMA and PCA) of a rust genus Maravalia was conducted by using techniques available in the FACOM-M340 computer program package (ANALYST SOFTWARE). The results support Cummins and Hiratsuka's suggestion (Cummins and Hiratsuka, 1983) that Chaconiaceae should include the genus Maravalia. However, the results gave a different idea of its relationship to the genus Ochropsora. The analysis also support the proposal that Atelocauda ,Pileolaria and Uromycladium should belong together in the family Pileolariaceae but that they are not closely related to the genus Uromyces.

Key Words: cluster analysis, Maravalia, numerical taxonomy, Ochropsora, principal component analysis.

The application of numerical method has not been very extensive in fungi (Sneath and Sokal, 1973). Proctor and Kendrick (1963) were the first to employ numerical method in fungal systematic research. More than 30 papers on numerical taxonomy of fungi have been published, the method has been employed in Fungi Imperfecti, Ascomycotina and Basidiomycotina (Dai, 1988). Machol and Singer (1971) described a numerical taxonomic technique for assigning lower level taxon (genus) to one of several higher level taxa(families)to which it seemed related.

The numerical taxonomic method appears intuitively satisfying because it represents a quantitative description of what the taxonomist normally does. Furthermore, it satisfies the criterion of objectivity required by numerical taxonomy in that it uses all known characters (or as many as desired), and has no a priori weighting. By examining the final computer printout it is easy to see exactly which characters are important and the extent to which they control the final conclusion. Although numerical taxonomy has many rational aspects, it can not replace the traditional taxonomy at present, especially in identification of specimens. The main problem is to make a coding system of characters which will be accepted by most taxonomists. There are many characters in rust fungi that can be used for numerical method. Rust fungi occur in nature only as parasites of living plants. The hosts are thus important for taxonomy of rust fungi. Therefore, it is important how the character of host is used for numerical method; this needs continued study.

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The genus Maravalia was established by Arthur in 1922, but opinions vary about its suprageneric position. Dietel (1928) classified Maravalia in the tribe Ravenelieae of the Pucciniaceae, but this classification was based on the probasidial formation in Maravalia albescens, which was actually Chaconia alutacea (Mains 1939). Mains (1939) suggested that Maravalia should be classified in the tribe Eriosporangieae rather than the Ravebekueae,but he also believed that Maravalia was more closely related to Chaconia, Chrysocelis and Olivea of the tribe Oliveae than to the Eriosporangieae. Leppik (1972) placed Maravalia together with Chrysocelis in the tribe Maravalieae of the Pucciniaceae, but the Maravalieae was not validly published. The close relationship of Maravalia to genera of the Oliveae was suggested, although the former genus has pedicellate probasidia and the latter sessile probasidia (Ono,1978). Based partly on Ono's study and according to the type of the spermogonia, Cummins and Hiratsuka (1983) classified Maravalia in the newly proposed family Chaconiaceae together with Chaconia, Chrysocelis, Ochropsora and Olivea. Ono and Hennen (1984), however, have thoroughly studied Maravalia and related genera and consider that they should not be classified in the Chaconiaceae, primarily because Maravalia has pedicellate teliospores and Chaconia has sessile teliospores. The taxonomic significance of probasidium pedicels is uncertain. Moreover, Maravalia and related genera also have some affinity to the Pileorariaceae in Cummins and Hiratsuka's system. Ono (1984) did not assign Maravalia to any suprageneric categories because these genera exhibit characteristics intermediate between Chaconiaceae and Pileolaliaceae, but neither is suitable to include these genera. Therefore, Maravalia has been placed in different suprageneric categories by different uredinologists who emphasized different characters.

The purpose of this paper is to evaluate taxonomic position of Maravalia by the numerical method suggested by Sneath and Sokal (1973) as executed by the FACOM--M340 ANALYST computer programs package.

MATERIALS AND METHODS

The operational basis of numerical taxonomy was presented by Sneath and Sokal(1973). In our study 34 non-redundant, equally weighted qualitative characters representing 10 OTU's were assembled into a basis data matrix(omited). Since the characters were qualitative and multistate, they were entered into the software using a duality coding system. Cluster analysis and principal component analysis were produced from the original matrix. The association coefficient was suggested by Sokal and Michener (Sneath and Sokal,1973). Cluster analysis was performed upon the OTU's by means of the UPGMA method (Unweighted Pair-Group using Arithmetic Averages). UPGMA cluster analysis was employed to generate a dendrogram; and principal component analysis (PCA) was the ordination method used to produce three-dimensional projection of OTU's. PCA with a strict mathematical basis is different from cluster analysis. It not only gives the projection graph but also shows the biological meaning of data by linking the intermediate information; cluster analysis does not have this function.

The following genera(OTU's)were studied in numerical analysis:

OTU1	*Chaconia*	OTU2	*Chrysocelis*
OTU3	*Ochropsora*	OTU4	*Olivea*
OTU5	*Maravalia*	OTU6	*Pileolaria*
OTU7	*Uromycladium*	OTU8	*Atelocauda*
OTU9	*Puccina*	OTU10	*Uromyces*

The characters of these genera have been described in detail (Cummins 1959; Cummins and Hiratsuka 1983; Mains 1939; Ono 1984 a,b; Ono et al.,1983; Thirumalachar et al., 1949, 1950, 1955). The authors chose 34 non-redundant characters in spermogonia, aecia, uredinia, telia, and physiology or ecology of these 10 genera.

The following 34 non-redundant qualitative characters were used in these analyses:

(i) Spermogonia
1 type--a. type4, b. type5, c. type7
2 position--a. subepidermal, b. subcuticular
3 paraphyses--a. present, b. absent
(ii) Aecia
4 position--a. subcuticular, b. deep-seated
5 central round pore--a. present, b. absent
6 paraphyses--a. present, b. absent
7 peridium--a. present, b. absent
8 type--a. aecidioid, b. uredinoid
9 formation of aeciospore--a. single, b. catenulate
10 surface ornament of aeciospore--a. verrucose, b. echinulate, c. reticulated, d. longitudinal lines, e. smooth
(iii) Uredinia
11 position--a. subepidermal, b. substomatal
12 peridium--a. present, b. absent
13 paraphyses--a. present, b. absent
14 formation of urediospore--a. single, b. catenulate
15 surface ornament of urediospore--a. verrucose, b. echinulate
16 germ pore--a. distinct, b. not distinct

17 germ pore arrangment of urediospore--a. equatorial, b.zonate, c. various
18 color of urediospore--a. present, b. absent
19 aecial uredinia--a. present, b. absent
20 aecial urediospore--a. present, b. absent

(iv) Telia

21 position--a. subepidermal, b. substomatal
22 waxy--a. yes, b. no
23 cells of teliospore--a. single, b. two-celled, c. many-celled
24 formation of teliospore--a. present, b. absent
25 pedicels of teliospore--a. present, b. absent
26 basal cell of teliospore--a. present, b. absent
27 branched pedicel--a. present, b. absent
28 cystidia of teliospore--a. present, b. absent
29 wall pigmented--a.present, b.absent
30 wall of teliospore--a. thin, b. thick
31 shape of teliospore--a. ovate or globose or ellipsoid, b. clavate or cyclindrical, c. discoid, d. cup shaped

(v) Physiology and ecology

32 germination of basidium--a. internal, b. external
33 germination of teliospore--a. dormancy, b.nodormancy
34 life cycle--a. heteroecious, b. autoecious

RESULTS AND DISCUSSION

The results of UPGMA cluster analysis are presented graphically in Fig. 1. Results of PCA ordination are presented in Figs. 2, 3, and 4; the first three principal component included 68.3% of all the information of characters.

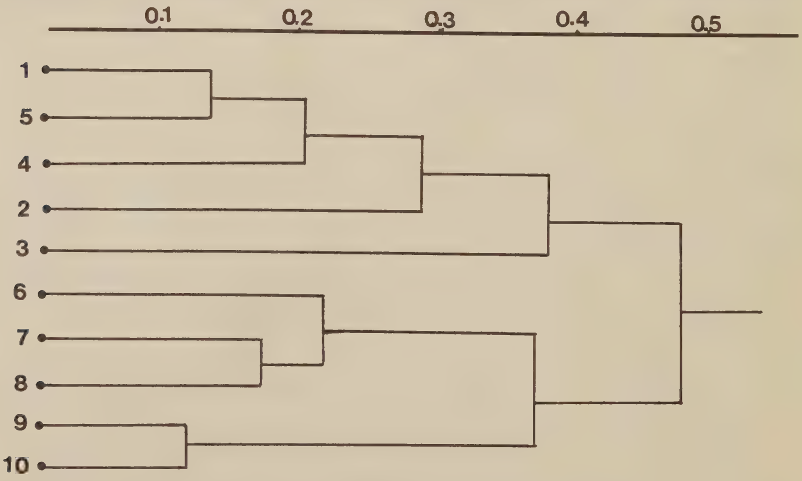

Fig. 1. Dendrogram of UPGMA cluster analysis of 10 OTUś

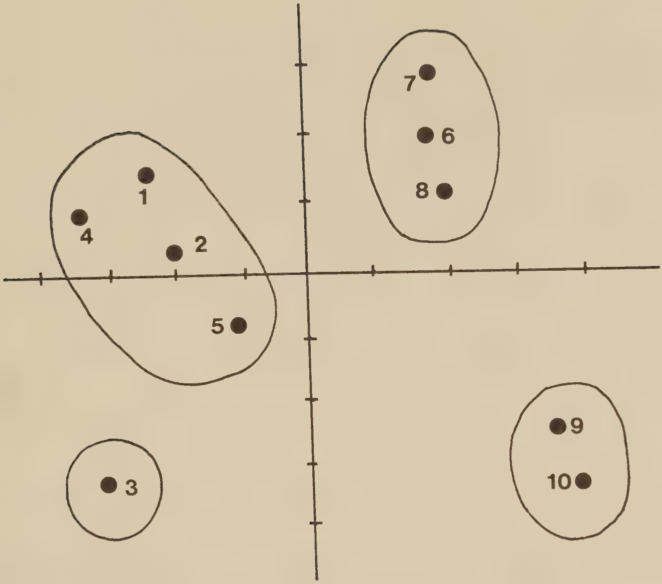

Fig. 2. Principal component analysis, 1, 2 components projection

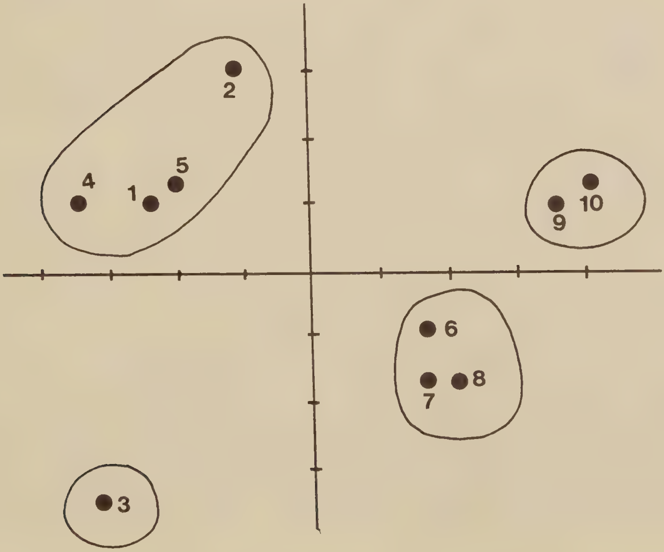

Fig. 3. Principal component analysis, 1, 3 components projection

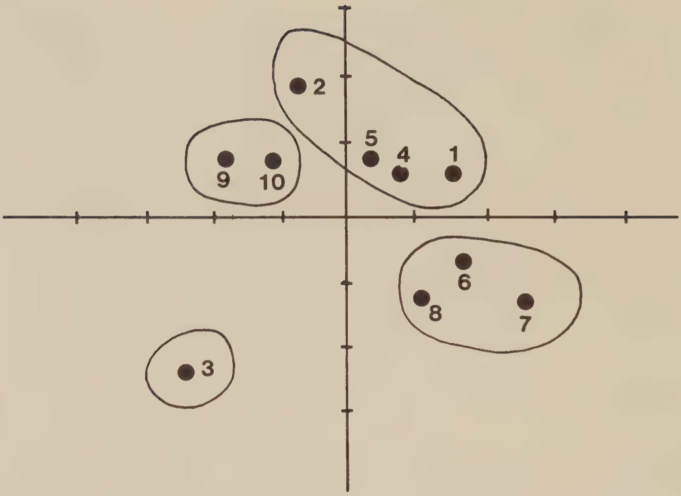

Fig. 4. Principal component analysis, 2, 3 components projection

It is evident from Figs. 1-3, that OTU5 (Maravalia), OTU1 (Chaconia), OTU4 (Olivea), and OTU2(Chrysocelis) are one group, while OTU6 (Pileolaria), OTU7 (Uromycladium), and OTU8 (Atelocauda) make up another group. The relationship of the 10 OTU's is also reflected in Fig. 4, although not as distinctly as in Figs. 2 and 3. Actually, Figs. 2, 3, and 4 are three-dimensional space coordinate graphs but because the cumputer printer only produces plane graphs, the space coordinate graphs turned into three projection drawings. If the three projection drawings were put together, the relationship of all OTU's would be clearer.

The factor load matrix of PCA indicated that the characters of the teliospore stage are important even though they are only one-third of all characters. Therefore, the characters of teliospore stage are more important than those of the spermogonia, aecia and uredinia in taxonomy.

PCA results indicate that the following characters are important: the presence or absence of pedicels on the teliospore, germ pore of teliospore, thickness and color of teliospore wall, sporogenous basal cells of teliospore, germination of teliospore with or without dormancy, teliospore shape, and the type of life cycle. Ono (1984) indicated that the main characters of Maravalia are that it has one-celled, thin-walled, hyaline, pedicellate probasidia (teliospores), the probasidia have no distinct germ pore and become four-celled metabasidia by simple apical extension without domancy. Main characters showed by PCA also indicated that the teliospore shape and the life cycle are comparatively important. Ono did not make any conclusion on taxonomic position of *Maravalia*.

The authors consider that it is preferablee to classify *Maravalia* in Chaconiaceae rather than in Pileolariaceae or as an independent suprageneric category because *Maravalia* is similar to *Chaconia* in most of the main characters. *Maravalia* resembles *Pileolaria* in some main characters (e.g. teliospore on pedicels), but it is different from *Pileolaria* in the chief characters of sporogenous basal cells, germ pore, thickness and color of wall, and shape of teliospores. It is identical or resemble *Chaconia* in these important characters; therefore, the results of numerical taxonomy support Cummins and Hiratsuka's (1983) suggestion. Cummins and Hiratsuka (1983) placed the genus *Ochropsora* in Chaconiaceae on the basis of the type of spermogonia. The results of numerical analysis show that *Ochropsora* is not closely related to *Chaconia*, *Chrysocelis*, *Maravalia*, and *Olivea*. Ten OTU's would be divided into 4 groups if the dendrogram were cut off at a similarity level of 0.35 in Fig. 1. OTU1, 2, 4, and 5 are in one group, OTU3 alone is a group, OTU6, 7, and 8 are a group, OTU9 and 10 are a group. Similar results are also reflected in Figs. 2, 3, and 4. The authors consider it is unsuitable to place *Ochropsora* in Chaconiaceae, because the character of germination in basidium (internal or external) is stable and, therefore, this character is important in taxonomy. *Ochropsora* is similar to *Maravalia* in its type of spermogonia, but *Maravalia* and related genera are autoecious, without sporogenous basal cells on teliospores and have external basidia.

Thirumalachar (1949, 1955) considered *Atelocauda* and *Uromycladium* to be closely related to *Uromyces*. The only difference is the presence of subcuticular spermogonia in *Atelocarda* and subepidermal ones in *Uromyces*. The difference between *Uromycladium* and *Uromyces* is that the former has teliospore with cystidia. However, the results of numerical analysis show that *Atelocauda* and *Uromycladium* are more closely related to *Pileolaria* rather than to *Uromyces*. *Atelocauda* and *Uromycladium* are different from *Uromyces* in many important characters. In our opinion, it is suitable to include *Pileolaria*, *Atelocauda*, and *Uromycladium* in the new family Pileolariaceae, as suggested by Cummins and Hiratsuka (1983, 1984).

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DESCRIPTION AND PATHOGENICITY OF CALONECTRIA CLAVATA SP. NOV.

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ABSTRACT

A *Cylindrocladium* sp., now identified as *C. clavatum,* was isolated from root and organic debris removed from nonsterilized peat from southern peninsular Florida (Lee County). The fungus was later isolated from roots and stems of *Callistemon viminalis* grown in soil mixes containing the same peat. Pairing of the two mass isolates on propylene oxide-fumigated woody stem pieces of *Arachis hypogaea* on water agar and on stem pieces of *Rhododendron* sp. on water agar yielded perithecia under ambient laboratory conditions. Pairing (all possible combinations) of 27 monoascospore cultures derived from these perithecia resulted in the production of perithecia in 170 of 351 crosses. Perithecia were not produced in unpaired cultures, thus indicating a bipolar heterothallic sexual compatibility. *Calonectria clavata* sp. nov. is proposed for the binomial of the heterothallic sexual state which is heretofore undescribed. This fungus is shown to be a pathogen on *Eucalyptus viminalis* seedlings.

Key Words: *Calonectria clavata, Cylindrocladium clavatum, Eucalyptus viminalis.*

INTRODUCTION

In 1978, during routine clinical diagnoses at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry's Plant Pathology Laboratory in Gainesville, we isolated a *Cylindrocladium* sp. (Accession No. 078-1261) from root and organic debris removed from nonsterilized peat mined in Lee County in southern peninsular Florida. The same organism (Accession No. 078-1543) was subsequently recovered from roots and stems of bottlebrush [*Callistemon viminalis* (Sol. ex Gaertn.) Cheel] grown commercially in soil mixes containing the same peat. This paper reports the specific identity of this fungus as *C. clavatum* C. S. Hodges & L. C. May, the initial description of the heterothallic nature of its *Calonectria* teleomorph (16-18), and preliminary evidence of its apparently restricted pathogenicity.

METHODS AND MATERIALS

Original mass isolates of a *Cylindrocladium* sp. were isolated from infected roots surface-sterilized with 0.3% sodium hypochlorite for 3 min. and plated on acidified potato dextrose agar (APDA). APDA was prepared using the broth of 200 g of freshly peeled, diced and boiled Irish potatoes (*Solanum tuberosum* L.) to which was added 20 g dextrose, 1 g KH_2PO_4, and 18 g Difco Bacto agar, and which was then made up to 1 liter with deionized water, and adjusted to pH 4.3 with lactic acid after autoclaving.

Since some species of *Calonectria* are heterothallic and we were unable to induce perithecia with single cultures, mass isolates 078-1261 and 078-1543 were paired on peanut (*Arachis hypogaea* L.) stem/water agar (PS/WA) and azalea (*Rhododendron* sp.) stem/water agar (AS/WA) to enhance sporulation and promote perithecial formation (19). PS/WA was prepared by pouring cooled (50°C), autoclaved water agar (WA) over dried, propylene oxide-fumigated (8) pieces of peanut stem (4-6 cm long) which floated or became partially submerged upon solidification of the agar. AS/WA was prepared in the same manner as PS/WA.

Paired cultures were incubated at room temperature (25 $\pm$ 2°C) under ambient laboratory conditions and were observed over a 4-week period. Water-mounted conidiophores and conidia were photographed when cultures were 1-week old. Conidiophore branches, phialides, and vesicles were measured within 5 min. of preparation to avoid swelling of structures. Conidia produced on the peanut stem were mounted in cotton blue lactophenol for measurements.

Single ascospore cultures were obtained by the method of El-Gholl *et al.* (6) and were maintained on potato dextrose agar.

Microscopic examinations and measurements were made on 49 primary branches, 33 secondary branches, 4 tertiary branches, 39 phialides, 48 vesicles, 200 conidia, 119 perithecia, 101 asci, and 250 ascospores at X400 or X1000.

Pathogenicity

Root inoculations

Isolates 078-1261 and 078-1543 were grown on "V-8" agar slants at room temperature under continuous fluorescent lighting (GE F20 T12-CW). "V-8" juice agar was prepared by mixing 2.5 g $CaCO_3$ in 177 ml of Campbell's "V-8" juice and centrifuging for 3 min. at a relative centrifugal force of 650 x g. To each 100 ml of supernatant, 400 ml of deionized water was added, resulting in a clear "V-8" broth with a pH of ca. 6.0. To each litre of this broth, 18 g of Difco bacto agar was added. After 10 days, inoculum suspensions which consisted of conidia, hyphal fragments, and microsclerotia were prepared by comminuting 10 slants of each isolate in 500 ml of deionized water in a Waring blender.

Callistemon viminalis, 6 *Eucaluptus* spp. (*E. camaldulensis* Dehnh., *E. cinerea* F. v. Muell. ex Benth., *E. grandis* W. Hill ex Maiden, *E. robusta* Sm., *E. torelliana* F. v. Muell., *E. viminalis* Labill.), and 4 *Pinus* spp. [*P. clausa* (Chapm. ex Engelm.) Vasey ex Sarg. var. *clausa*, *P. clausa* (Chapm. ex Engelm.) Vasey ex. Sarg. var. *immuginata* Warder, *P. elliottii* Engelm., *P. elliottii* Engelm. var. *densa* Little & Dorman, *P. palustris* Mill., *P. taeda* L.] were inoculated with each of the two *C. clavatum* isolates. These hosts have been reported to be susceptible to *C. clavatum* (2,9,12,14). Roots were inoculated by applying 20 ml of the "V-8" culture suspensions as a drench on the soil surface near the base of the test plant. Three replications were used for each host. Control plants were similarly treated with comminuted "V-8" agar slants, but without the fungus.

Foliage inoculations

Stem pieces (ca. 5 cm x 1-2 mm) of *Eucalyptus* sp. were used as a natural medium for the production of conidia for foliage inoculations. The stem pieces were sterilized with propylene oxide (8) and were inserted slightly into the surface of WA slants (1 stem piece/slant). Plugs (ca. 3 mm in diam.) were cut from actively growing cultures and placed on the agar surface (1 plug/slant) next to the stem piece. Slants were incubated for 10 days at room temperature under continuous fluorescent lighting as indicated above. Conidial suspensions were then prepared by adding aliquots of sterile deionized water (SDW) to the slants and shaking vigorously on a Vortex mixer. Washings were combined and filtered through 4 layers of cheesecloth and a 38 μm sieve to remove unwanted agar fragments and then diluted to approximately 10,000 conidia per ml. Conidial suspensions were applied to the foliage of test plants with a glass atomizer. Fifteen ml were applied to plants of *C. viminalis* (2 plants per pot) and *Eucalyptus* spp. (2 plants per pot). *Pinus* spp. received 5 ml (1 plant per pot) except for *P. elliottii* which received 10 ml per pot. Control plants were similarly treated using only SDW. Immediately following inoculation, test plants were covered with polyethylene bags and placed on a greenhouse bench for incubation. Two days later, the bags were removed and observations were made periodically for a period of 2 months.

Conidial suspensions of both isolates were also tested on leatherleaf fern [*Rumohra adiantiformis* (G. Forst.) Ching] foliage. Leatherleaf fern is known to be highly susceptible to *Cylindrocladium floridanum* Sobers & C. P. Seymour, *C. heptaseptatum* Sobers, Alfieri, & J. F. Knauss, *C. pteridis* F. A. Wolf, and *C. scoparium* Morgan (20-22). For comparison, leatherleaf ferns (3 replications) were similarly inoculated with *C. pteridis* (10,000 conidia/ml). Fifty ml were applied per plant. Control plants were sprayed with SDW.

RESULTS AND DISCUSSION

Identification

Individually, isolates 078-1261 (= ATCC 66388) and 078-1543 (= ATCC 66389) did not produce perithecia on PS/WA or AS/WA, but by pairing them, we were able to induce perithecia on both media. Perithecia were mostly produced on the stem pieces, but some were embedded in the agar. Perithecia required 3 to 4 weeks for ascospore formation (Fig. 1). From the induced perithecia, we were able to establish cultures from single ascospores on APDA. These cultures were fairly uniform in colony morphology; however, there were differences in growth rate. Twenty seven monoascospore cultures were paired in all possible combinations on AS/WA. Results are shown in Table 1. Unpaired single ascospore cultures did not produce perithecia. Single ascospore isolates fell into two (+/-) sexual compatibility groups, indicating bipolar sexual compatibility. Isolates 2, 3, 4, 7, 9, 11-14, 16-18, 21-24, and 26 belonged to one group (total of 17)

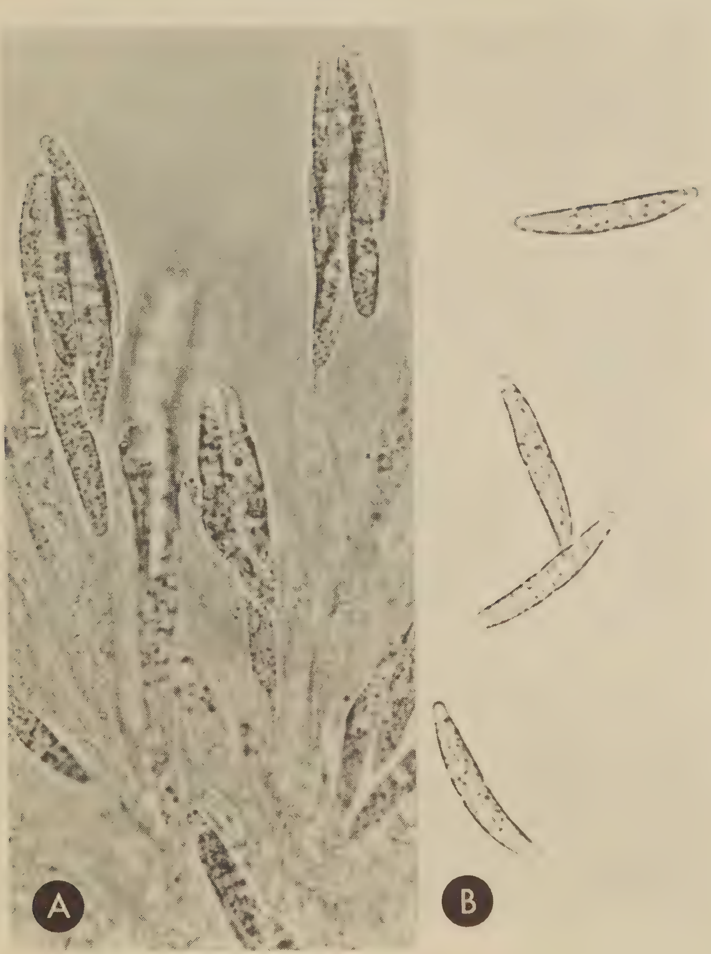

Fig. 1. *Calonectria clavata.* A) Asci x578. B) Ascospores x578.

designated as mating type S+. Isolates 1, 5, 6, 8, 10, 15, 19, 20, 25, and 27 belonged to the other group (total of 10) designated as mating type S-. The fungus is therefore a heterothallic species.

Morphologically, isolates 078-1261 and 078-1543 are similar to *C. clavatum* type culture ATCC 22833, but have longer conidia (Table 2). Conidiophores produced 1-septate conidia and a filament terminating in a clavate vesicle (Fig. 2). *Cylindrocladium pteridis*, though morphologically similar to *C. clavatum*, produces much longer and wider conidia and much wider vesicles (20). Comparative conidial measurements of *C. clavatum* from 3 distinct geographical locations suggest substantial variation in length among isolates (Table 2). Conidial measurements from 6 monoascospore cultures of the Florida teleomorph show a consistency with the original mass isolates (Table 3).

Macroscopic and microscopic characteristics of induced perithecia were typical of *Calonectria* spp. (16-18). This represents the first report of a sexual state of *Cylindrocladium clavatum*. This teleomorph (Fig. 1) is different from all known species of *Calonectria* with *Cylindrocladium* imperfect states which produce clavate vesicles (Table 4), and represents the first report of a sexual state for *C. clavatum*. Thus a new species, *Calonectria clavata*, is proposed.

Calonectria clavata Alfieri, El-Gholl, *et* Barnard, *sp. nov.*

Perithecia superficialia in substrato, solitaria vel in gregibus parvis, aurantiaca vel atroaurantiaca, pariete externo aspero verrucoso, e typis sexualibus idoneis in fragmentis caulium *Arachidis hypogaeae* et speciei *Rhododendri* super agarum aquosum educta, (364-)499(-626) µm alta, (293-)423(-505) µm lata; asci (53-)97 (-155)x(10-)17.8(-22.5) µm; ascospora 1- ad 3-septata, (30-)41 (-54)x(4-)5.5(-6.5) µm.

Holotypus: FLAS F55430, mense Augusto 1989. In fragmentis caulium *Arachidis hypogaeae*: in laboratorio DPI, Doyle Conner Building, Gainesville, Florida, inducta a coniugio *Cylindrocladii clavati* 078-1261 (seiuncti e fragmentis radicum in recente sphagno non sterilizato, a Don Ferrin, Ft. Myers, Florida, 4/3/78 lecti) et 078-1543 (seiuncti e radicibus caulibusque

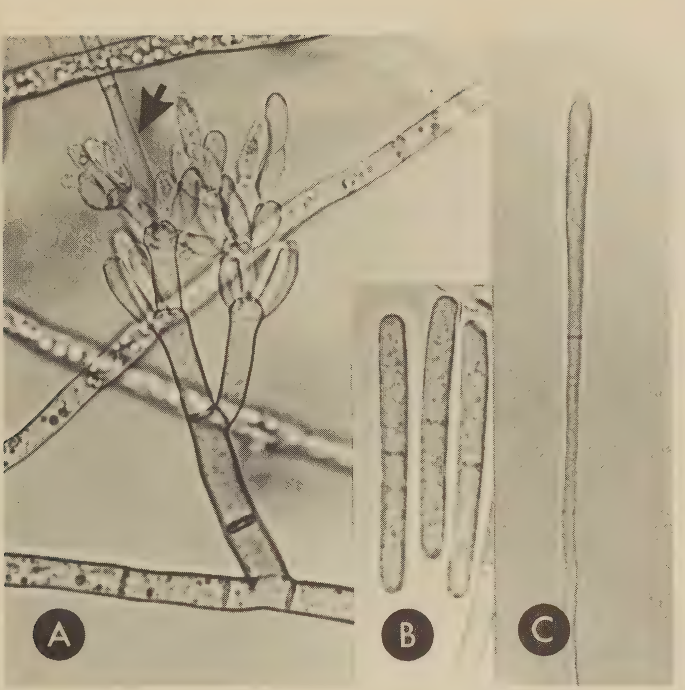

Fig. 2. *Cylindrocladium clavatum.* A) Conidiophore arising from a mycelial cell x578. Filament is indicated by an arrow. B) 1-septate conidia x578 (insert). C) Filament terminating in a clavate vesicle x578.

Callistemonis viminalis, a C. P. Seymour & E. L. Barnard, Lake Placid, Florida, 5/4/78 lecti).

Perithecia superficial on substrate, borne singly or in small groups, orange to dark orange, with rough, warted outer wall. With appropriate mating types perithecia were induced on *Arachis hypogaea* and *Rhododendron* sp. stem pieces on water agar. Perithecia (364-)499(-626)μm high; (293-)423(-505)μm wide; asci(53-)97(-155)x(10-)17.8(-22.5)μm; ascospores 1- to 3-septate, (30-)41(-54)x(4-)5.5(-6.5)μm.

Holotype: FLAS F55430, August 1989.
Stem pieces *Arachis hypogaea*: Induced in lab, DPI, Doyle Conner Bldg., Gainesville, FL, by mating *Cylindrocladium clavatum* isolate 078-1261 (from root debris in unused nonsterilized peat, collected by Don Ferrin, Ft. Myers, FL, 4/3/78) and 078-1543 (from *Callistemon viminalis* roots & stems, collected by C. P. Seymour & E. L. Barnard, Lake Placid, FL, 5/4/78.

The two sexually compatible isolates 078-1261 and 078-1543 were deposited in the American Type Culture Collection, 12301 Parklawn Drive, Rockville, Maryland 20852, U.S.A. as ATCC 66388 and ATCC 66389, respectively.

Pathogenicity

Only *Eucalyptus viminalis* was susceptible to inoculations with Florida isolates 078-1261 and 078-1543. One to 2 weeks following inoculation, small, tan, circular to irregular leaf spots began to appear in abundance on leaves of this host (Fig. 3). Spots averaged 1-3 mm in diameter, had no discrete margin or halo, and occasionally coalesced to form larger spots, especially near leaf tips where moisture was prone to accumulate. A few small brown lesions, similar in appearance to the leaf spots, occurred on green portions of seedling stems as well. After 2 weeks, several inoculated seedlings began to exhibit severe wilting, and shriveling of foliage (Fig. 3). During the subsequent 4 weeks, two of 8 and 9 of 10 seedlings inoculated with isolates 078-1261 and 078-1543, respectively, died. Roots of all seedlings exhibiting wilt and mortality were discolored, flaccid, and/or completely necrotic. Root collars of affected seedlings were water-soaked and brown to black

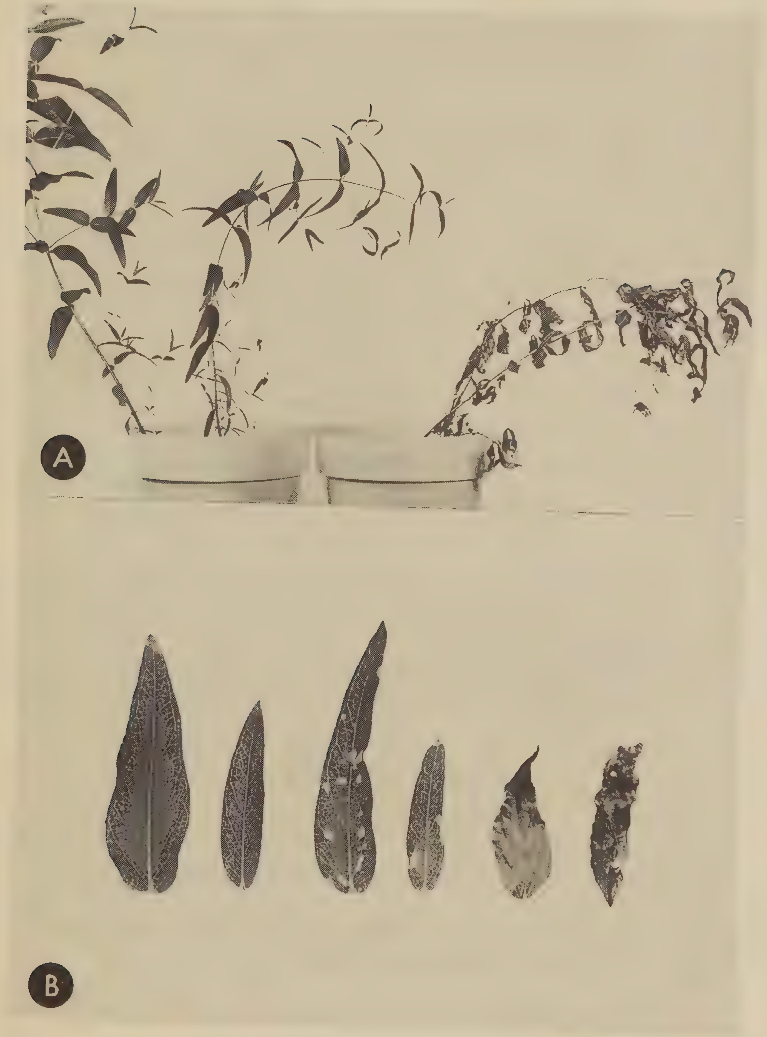

Fig. 3. Symptom expression of *Eucalyptus viminalis* seedlings infected with *Cylindrocladium clavatum*. A) Severe wilt resulting from root and root collar infection (right). Control plants shown at left. B) Foliage symptoms (left to right): symptomless controls, leaf spots, and leaf shriveling.

in color. Control plants remained symptomless. *Cylindrocladium clavatum* was recovered from leaf spots, stem lesions, and symptomatic roots and root collars. The fungus was not recovered from control plants or any other inoculated host.

Neither isolate infected leatherleaf fern foliage. *Cylindrocladium pteridis* caused leaf spots similar to those reported by Sobers (20).

Why only *E. viminalis* succumbed to inoculations with our Florida isolates of *C. clavatum* is uncertain. Hodges and May (9) reported pathogenicity for *C. clavatum* on several *Pinus* spp., as well as a variety of other hosts including *E. saligna* Sm. It is possible that the Florida isolates represent a relatively nonvirulent strain of *C. clavatum*. Limited inoculations of *Araucaria heterophylla* (Salisb.) Franco and *Pinus* spp. with *C. clavatum* type culture (ATCC 22833) and with ATCC 64720 (Florida isolate of *C. clavatum* from roots of *A. heterophylla*) produced few infections, and evidence that Florida isolates of *C. clavatum* are a threat to plant/tree culture in Florida is lacking (2).

However, the possibility that variations in experimental technique account for the apparent differences cannot be overlooked. Hodges & May (9) employed a wound inoculation technique on stems and a technique which may have wounded roots in their studies. Our inoculations were performed on nonwounded plants.

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Contribution No. 683, Divisions of Plant Industry and Forestry

Table 1. Sexual compatibility of 27 isolates of *Cylindrocladium clavatum* which were derived from single ascospores of *Calonectria clavata* obtained from ATCC 66388 × ATCC 66389 on stem pieces of *Rhododendron* sp. partially immersed in water agar.

MONOASCOSPORE ISOLATE NO.

MONOASCOSPORE ISOLATE NO.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	▨−																										
2	+	▨−																									
3	+	−	▨−																								
4	+	−	−	▨−																							
5	−	+	+	+	▨−																						
6	−	+	+	+	−	▨−																					
7	+	−	−	−	+	+	▨−																				
8	−	+	+	+	−	−	+	▨−																			
9	+	−	−	−	+	+	−	+	▨−																		
10	−	+	+	+	−	−	+	−	+	▨−																	
11	+	−	−	−	+	+	−	+	−	+	▨−																
12	+	−	−	−	+	+	−	+	−	+	−	▨−															
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17	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	▨−										
18	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	▨−									
19	−	+	+	+	−	−	+	−	+	−	+	+	+	+	−	+	+	+	▨−								
20	−	+	+	+	−	−	+	−	+	−	+	+	+	+	−	+	+	+	−	▨−							
21	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	▨−						
22	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	−	▨−					
23	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	−	−	▨−				
24	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	−	−	−	▨−			
25	−	+	+	+	−	−	+	−	+	−	+	+	+	+	−	+	+	+	−	−	+	+	+	+	▨−		
26	+	−	−	−	+	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	−	−	−	−	+	▨−	
27	−	+	+	+	−	−	+	−	+	−	+	+	+	+	−	+	+	+	−	−	+	+	+	+	−	+	▨−

Shading indicates selfing

− = Perithecia were not produced

+ = Perithecia were produced

TABLE 2. Comparative conidial measurements (μm) of *Cylindrocladium clavatum* type culture with two *C. clavatum* isolates from Florida and one from Mauritius. Number in parentheses indicates literature citation.

ATCC 22833 (Isolate from Brazil)	37.6 - 47.9 x 3.4 - 5.6 Mean 42.1 x 4.7(9)
ATCC 66388 (Isolate from Florida)	30 - 72 x 4 - 5.5 Mean 53 x 5
ATCC 66389 (Isolate from Florida)	28 - 70 x 3.8 - 5 Mean 53 x 4.9
Isolate from Mauritius	36.4 - 59.8 x 3.2 - 5.2(12)

TABLE 3. Conidial measurements (µm) of six *Cylindrocladium clavatum* cultures* which were derived from single ascospores (SA) obtained from ATCC 66388 x ATCC 66389.

	Length			Width		
	Min.	Mean	Max.	Min.	Mean	Max.
SA 1	(27.5 -)	56.9	(- 80.0)	x (3.3 -)	4.8	(- 5.5)
SA 2	(30.0 -)	51.1	(- 72.5)	x (3.5 -)	4.9	(- 5.5)
SA 3	(27.5 -)	53.6	(- 72.5)	x (2.8 -)	4.5	(- 5.0)
SA 4	(40.0 -)	53.7	(- 65.0)	x (3.8 -)	4.9	(- 5.0)
SA 5	(26.3 -)	64.7	(- 83.8)	x (3.0 -)	4.9	(- 6.0)
SA 6	(30.0 -)	62.6	(- 80.0)	x (3.0 -)	4.9	(- 5.0)

* 100 conidia per isolate grown on peanut stem water agar were measured.

TABLE 4. Comparison of 6 species of *Calonectria* with *Cylindrocladium* imperfect states which produce clavate vesicles. Number in parentheses indicates literature citation.

	Perithecia (height x diameter, µm)	Asci (µm)	Ascospores (µm)	Vesicles (µm)	Phialides (µm)	Conidia (µm)
Calonectria clavata	Orange to dark orange 364-626x293-505 Mean 499x423	8-spored 53-155x10-22.5 Mean 97x17.8	1-to 3-septate 30-54x4-6.5 Mean 41x5.5	Clavate 3-5.5 wide Mean 4.4	Doliiform, cylindrical, lageniform or slightly reniform 10-18.8x3-4.8 Mean 13x3.8	1-septate 28-72x3.8-5.5 Mean 53x5
Calonectria colhounii Peerally	Initially yellow 247-463x309-515(11)	4-spored 104-156x13-18.2(11)	3-septate 33.8-84.2x4.4-7.8 Mean 60x6.2(11)	Clavate 2-5.2 wide (11)	7-13.6 long (11)	3-septate rarely 1- or 2-septate 38.3-84.2x3.4-5.7(11)
Calonectria hederae Booth & Murray	Orange to red 300-370x200-300(4)	8-spored 160-180x24-40(4)	3-septate 45-65x6-8(4)	Clavate or oval 30-40x8-10(4) 6.4-14.4 wide (11)	Doliiform 12-15x5-6(4)	3-septate 60-80x6-8(4) 44.2-102x5.6-9.2(11)
Calonectria ilicicola Boedijn & Reitsma	Orange 400-500x320-370(3)	8-spored 110-140x16-18(3)	1- to 3-septate 38-57x5-7(3)	Clavate 5-11.2 wide (13)	8-16x3-4(3) 10.2-13.6 long (13)	Mostly 3-septate 49-69x4.5-6(3) 37.4-68x4-5.2(13)
Calonectria quinqueseptata Figueiredo & Namekata	Orange to chestnut 360-580x300-440(7)	8-spored 76-126x13-22(7)	1- to 6-septate mostly 3-septate 30-80x4-7(7)	Clavate 12x2.5-3(3)	11-12x2-3(3)	5-septate 75-106x5-7(3)
Calonectria theae Loos	Orange to red 340-440 diam. (10) 273-475x250-475 Mean 374x371(5) 248-481x227-382 Mean 374x313(1)	8-spored 99.2-145.5x16.3-25.8 Mean 122.6x21.3(1)	1- to 3-septate 42-70x5-8 Mean 57.9x7(10) 42.2-77.5x5.9-8.3 Mean 54.7x7.4(1)	Clavate 13.6-28.7x4.1-8.2(1)	Mostly reniform, banana-shaped 7.7-16.5x3.5-5.3(1) 13-15.5x2.9-3(10)	Mostly 3-septate 62-100x3.5-6.5 Mean 76.6x5.2(10) 57.1-95.2x4.7-7.1 Mean 79.3x5.8(1) 80-120x8(15)

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OMPHALOTUS OLIVASCENS VAR. *INDIGO, VAR. NOV.* FROM BAJA CALIFORNIA (MEXICO)

by

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Summary. *Omphalotus olivascens* var. *indigo var. nov.* is described from Baja California (Mexico). This new taxon differs mainly from the type-varity in its blue flesh, very apparent when cut; this colour is kept in exsiccata and is lacking in all the previously taxa described in *Omphalotus, e.g. O. olearius, O. illudens* and *O. subilludens.*

Key words: *Omphalotus, Paxillaceae,* taxonomy, Baja California, Mexico.

During two short visits by one of us (GM) to Baja California, in the years 1989 and 1990, financed through a joint-research project between the Universities of Baja California (Mexico) and Alcalá de Henares (Spain), some collections of an *Omphalotus* taxon growing on *Quercus agrifolia* stumps, attracted our attention owing to the deep violet-blue colour of its flesh, readily seen when cut. This colour, undescribed in any *Omphalotus* taxa up to date, is also maintained in herbarium.

Preliminary chemotaxonomical studies on the individual pigment patterns of typical collections of *O. olearius, O. olivascens* and the new taxon have been made; in contrast to the striking diversity of the flesh colour, the results of chromatographical analysis (TLC) did not show any reliable qualitative differences between *O. olivascens* and the new variety.

Omphalotus olivascens var. ***indigo***, *var. nov.* (Figs. 1-10)

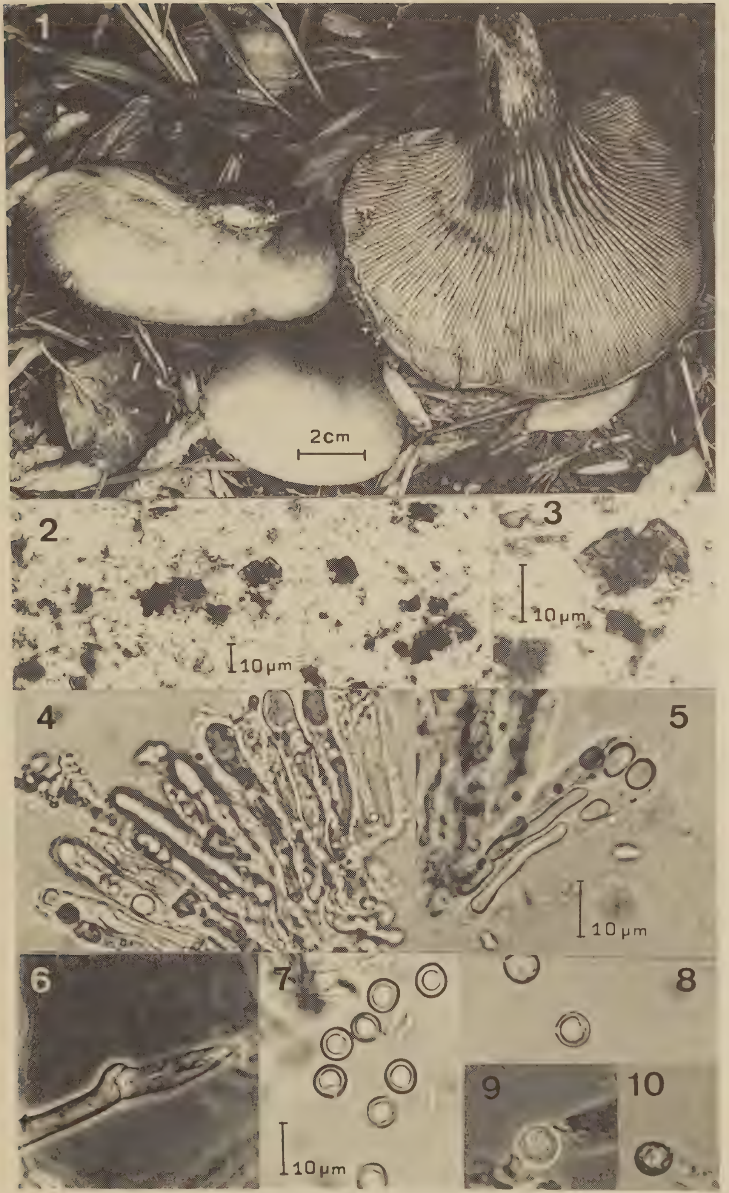
Species colore carnis caeruleo notata, cum sectio fit et in herbarium. In truncis Quercus agrifolia. San Antonio de las Minas (Baja California, Mexico). *Leg.* N. Ayala, C. Ochoa, R. Galán et G. Moreno, 10-III-1990. ***Holotypus* AH 13187.**

Caps 2-11 cm diam., convex, becoming applanate to depressed, orange-ochre with typical olivaceous tints, glabrous, smooth, streaked with innate radially-arranged darker fibrils; margin incurved at first, becoming decurved with age. Gills decurrent, yellow-olivaceous, becoming orange near the edge. Stipe 3-9 x 0,5-1,5 cm, cylindrical, often excentric and curved, concolorous, in clusters. Flesh yellow-olivaceous, turning inmediately blue-grayish. Small basidiomata fragments pulverized develop a violet colour instantly with 100% methanol. In some cases, fresh basidiomes show externaly the violet-blue colour which is always seen in the cut flesh.

Epicutis of pileipellis formed by clamped hyphae, 4-8 µm diam., with brown-reddish extracellular encrusting pigment and a yellowish intracellular pigmentation. Flesh of pileus, stipe and hymenophoral trama showing small dark (purplish-violet-blackish) granules at simple sight. Under the microscope, these granules show a brown-reddish colour and become bright violet under KOH 10% and ammonia solution, dissolving posteriorly and giving an uniformly green to yellowish-green colour to the preparation. Spores globose, 7-9 µm, hyaline, non-amyloid. Basidia 35-40 x 8-10 µm, clavate, 4-spored. Hymenophoral trama of subparallel hyphae. Cystidia not observed. Clamps present.

Lignicolous, usually on *Quercus agrifolia* (encino) stumps.

Figs. 1-10: *Omphalotus olivascens* var. *indigo*, 1: Fruitbodies, 2-3: extracellular encrusting pigment, 4-5: hymenium, 6: clamp-connection, 7-10: spores.


1
2cm
2
10µm
3
10µm
4
5
10µm
6
7
10µm
8
9
10

Material studied: ***Omphalotus olivascens* var. *indigo*** Moreno, Esteve-Raventós, Pöder & Ayala: On *Quercus agrifolia*, San Antonio de las Minas (Baja California Norte, México), *leg.* N. Ayala, C. Ochoa, R. Galán & G. Moreno, 1990-3-14, **AH 13187 *Holotypus***, *Isotypus in herb.* Singer, Pöder; *Ibidem*, El Junco, *leg.* N. Ayala & M. Lizarraga, 1992-3-10, AH 15512; *Ibidem*, *leg.* N. Ayala, 1992-3-25, AH 15513; *Ibidem*, 1992-4-5, AH 15514; *Ibidem*, Emiliano Zamora, Ensenada, *leg.* N. Ayala, 1992-3-10, AH 15515; *Ibidem*, Aguaviva, Ensenada, *leg.* M. Lizarraga, 1992-2-10, AH 15516; *Ibidem, Rancho la Fortuna, Tecate, leg.* J. Torres & M. Lizarraga, 1992-1-11, AH 15517; ***Omphalotus olivascens*** Bigelow, Miller & Thiers: Cespitose on dead oak stump, San Mateo Co., San Bruno, Junipero Serra Park, (California, U.S.A.), *leg.* H.D. Thiers, 1960-10-4, HDT 8547; ***Omphalotus olearius*** (DC: Fr.) Singer: On *Quercus ilex*, Var, Ile de Cros (France), *leg. & det.* M. Moser, 1978-10-31, IB 78/492.

This new variety of *Omphalotus olivascens* can be distinguished only macroscopically by the typical and apparent blue-violet flesh, which is instantly seen when the flesh is cut, sometimes also externally on caps and gills. Opposite to some boletes, this colour is permanently maintained in dry material. This character has not been previously described or commented in any *Omphalotus*, not even in *Omphalotus olivascens* which, according to the original description, does not show any violet-blue colour in fresh material (BIGELLOW & al., 1976). It is difficult to assume that this striking character has been overlooked by these authors when *O. olivascens* was originally described.

Omphalotus olivascens var. *olivascens* Bigellow, Miller & Thiers shares the same ecology, olivaceous colours and microscopical characters; it occurs in North and Central California. A comparative macroscopical study of material of typical *O. olivascens* sent by Thiers himself, has shown the same pigmentation as in var. *indigo*, but in a lesser quantity and intensity. Dr. Thiers (pers. comm.) however, has reported that he has never found any blue violet flesh in those fruitbodies of *O. olivascens* studied by him.

Recently, ARORA (1991:40-41) has published an interesting photograph of *Omphalotus olivascens*, commenting the use of this mushroom as a dying agent for wool; the colour of the dyed wool that is shown in the picture is strikingly similar to var. *indigo* flesh.

The doubts that arose before describing this new taxon, recommended us to use a chemotaxonomical analysis of the pigments of the material classified as a "new taxon, close to *olivascens*", and comparing it to the chemotaxonomical results already published; likewise, one of us (RP) accomplished the chemotaxonomical studies that are described next, using typical material of *Omphalotus olearius* and *O. olivascens* (from Thiers, HDT 8547) for comparison.

Methods: 200 mg of pulverized basidiomata fragments (cuticle, context and gills) were extracted 72h in warm methanol (99.9 % and 50 % aqu. dest.) following BRESINSKY & BESL (1979). The extracts were evaporated under vacuum to dryness and washed several times with ethyl acetate. The unsolved residues were resuspended in methanol (= extract 1). The combined ethyl acetate fractions were dried with Na_2SO_4 (= extract 2). Both extracts reduced to 5 ml were chromatographed on TLC Aluminium sheets SILICA GEL 60 F_{254} in different solvent systems (extract 2 in 1:1 benzene/ethyl acetate according to CAREY, 1974). The chromatographical behaviour and color relations were checked in day light, short and long waved UV before and after treatment with conc. sulphuric acid (50:50 H_2SO_4/methanol; 2-3 min. at 110 ºC).

Results: Both, the methanolic extracts of *Omphalotus olivascens* and its *variety* show striking violet colours. They are "brown-violet" for the former and "deep violet" (KORNERUP & WANSCHER, 1981) for the var. *indigo*. The extracts of *O. olearius* are yellow-ochrerish.

No reliable qualitative differences could be observed between the pigment patterns of the var. *olivascens* and var. *indigo*. Yellow, green and violet pigments could be detected. The most remarkable quantitative difference is given by the violet pigment, which is several times more concentrated in var. *indigo*. Although *Omphalotus olearius* has several bands in common with the *O. olivascens* taxa, its chromatographical finger print is quite different. Green and violet pigments could not be found.

So far, the striking violet pigment has not been mentioned in literature (comp. NAIR & al., 1983).

Finally, *Omphalotus olearius*, *O. illudens* and *O. subilludens* are all lignicolous taxa which never show olivaceous colours and grow on many kinds of substrata; they seem to share a less restricted distributional patterns, as it is known up to date. Some authors have reported that they are probably the same species, with only infraspecific taxonomical value (PEGLER, 1977 ; ROMAGNESI, 1978).

ACKNOWLEDGEMENTS

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The authors are also grateful and thank Dr. R. Singer for their invaluable comments and the revision of the new taxon.

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TULOSTOMA BECCARIANUM BRESAD., THE CORRECT NAME FOR *T.SIMULANS* LLOYD

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ABSTRACT– The type material of *Tulostoma beccarianum* Bresad. and *T.simulans* Lloyd are studied here and considered synonymous.

KEY WORDS– Tulostoma beccarianum, T.simulans, Gasteromycetes, chorology, taxonomy.

INTRODUCTION

The genus *Tulostoma* Pers.:Pers., as in many other groups of fungi, presents some taxonomic problems which require a solution. One of these is the acceptance of a relatively high number of doubtful or "critical" species. In many cases they have been collected only once or a few times, either poorly described or lack enough good differential features; frequently the holotypes are in poor shape, the collections are badly preserved or there is some other kind of difficulty to study them. Probably, many of these "critical" species are synonymous of other better known and more widely distributed species, but this is not easy to demonstrate in most cases owing to the above reasons.

In this paper we pay attention to *T.beccarianum*, a taxon described by Bresadola which is considered "critical" in Wright's (1987) world monograph. Actually, nobody has formerly paid any attention to this species, and the type seems to have not been studied, even by Wright himself (*loc.cit.*); this author remarks that he has not found the type and there exist few collections with this name, most of them belonging to other species.

Since the genus *Tulostoma* is being thoroughly studied by us, and this is a seemingly Mediterranean species, we endeavoured to locate the type–material in herbaria which keep most of Bresadola's collections.

We were lucky to obtain the loan of this type from the Herbarium of Naturhistoriska Riksmuseet in Stockholm (S). A description is appended.

DESCRIPTION

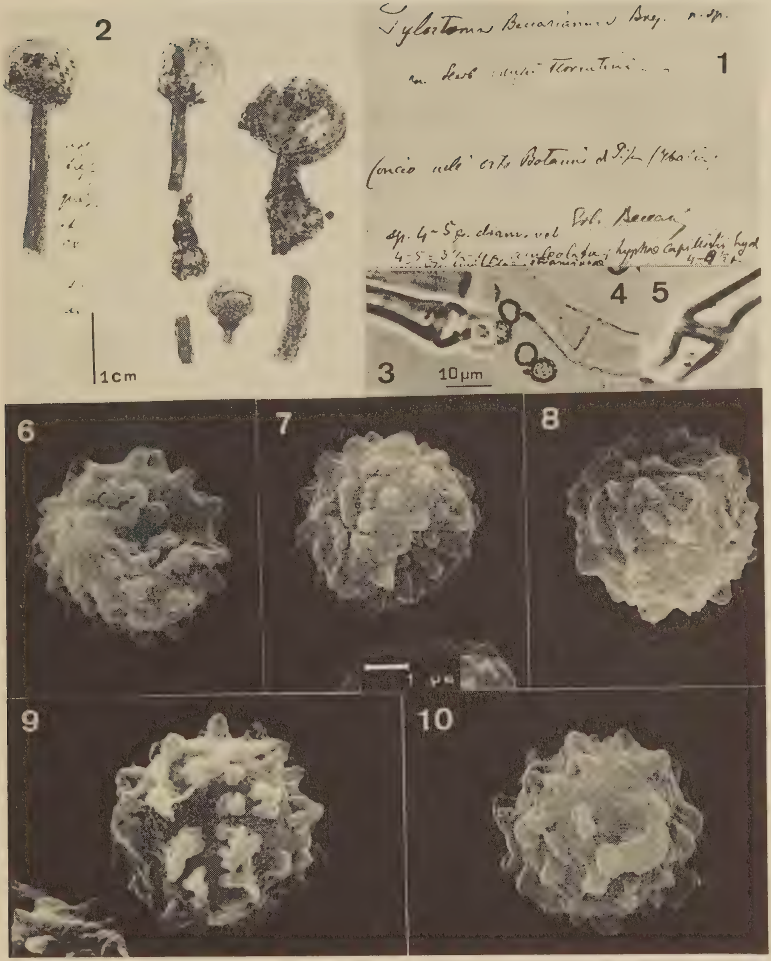
Tulostoma beccarianum **Bresad.** ***in*** **Petri,** *Ann.Mycol.* 2:413–414 (1904). (figs.1–8)

The type is composed by four fruit–bodies of different size, one of them glued on a piece of cardboard, and all of them with the stems more or less broken; however, this collection is in good condition to be studied. Spore–sac globose, 6–14 mm diam., exoperidium thinly membranous with some particles of soil adhered on it, and endoperidium finally smooth, pink to hazelbrown. Mouth circular, lip slightly projected, peristome concolorous with the endoperidium. Stem more or less cylindric, reddish brown, rough–striated, the best conserved one measuring 36 x 3 mm –however in the original description Bresadola (*loc.cit.*) recorded 30–60 x 2–4 mm–; widening at the base to 6–8 mm diam. Gleba ochraceous–rusty.

Capillitium hyaline to yellowish, branched, diameter variable but frequently similar to the spore diameter or larger; slightly swollen at the few septa. Spores globose, yellowish, 4,7–6 μm diam., verrucose; under SEM the ornamentation showing isolated middle–sized verrucae, some of them joined in groups or short crests.

REMARKS

During the study of *T.simulans* in Spain (Moreno & Altés, 1992), in which the type of this species was examined, as well as the type of *T.montanum* Pat. and *T.giovanellae* Bresad., we observed how easy it is to mistake some collections of both species with *T.simulans* (Lloyd was very cunning upon using this epithet). However, they can be easily separated with a careful microscopical


1
2
1cm
3
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8
1 µm
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10

Figs. 1–8. *T.beccarianum* holotype, Herb.Bresadola (S): 1. Bresadola's original label. 2. Fruit-bodies. 3–5. Capillitial septa. 6–8. Spores under SEM.
Figs. 9–10. *T.simulans* holotype, Herb.Lloyd 13636 (BPI): spores under SEM.

examination, specially under SEM. Although the spores and capillitium of the latter have been already illustrated in Moreno & Altés (*loc.cit.*), we include here some more microphotographs of these spores under SEM (figs.9–10).

On the other hand, when the features observed in *T.beccarianum* both by Bresadola and by us are compared with the features of *T.simulans*, it appears that these two species are closer than they appear at first.

	T.beccarianum (type)	T.simulans (type)
Spore-sac	6-14 mm diam., subglobose	9-11 mm diam., globose-subglobose
Exoperidium	thinly membranous	indistinct
Endoperidium	pink to hazelbrown colour	cream-ochraceous to copper-orange
Mouth	circular, lip slightly projected, next to 1 mm diam.	circular, prominent, somewhat tubular, next to 1 mm diam.
Stem	brown, slender, rough-striated, the best conserved specimen measuring 36 x 3 mm, widening at the base to 8 mm diam.	concolorous with the endoperidium, slender, rough-striated, measuring 22-35 x 2 mm, somewhat bulbous at the base (to 4 mm diam.)
Gleba	ochraceous-rusty	ochraceous-rusty
Capillitium	variable, mostly of the same diam. as the spore or larger, slightly swollen at the colourless septa	diam. as the spore or larger, swollen at the brown septa
Spores	globose, 4,7-6 µm diam., verrucose, with middle-sized verrucae under SEM	globose, 4,5-6 µm diam., verrucose, with more or less conic verrucae under SEM
Habitat	in garden soil	unknown

We believe that the differences between both taxa are insignificant. The fact that we define the exoperidium in the holotype of *T.simulans* like "indistinct" is not a clearly segregating feature with regard to the thinly membranous exoperidium of *T.beccarianum*. The differences shown by the exoperidium of both taxa fit within the range of variability of one single species. This has been verified in other collections of *T.simulans* (Moreno & Altés, *loc.cit.*), in which the exoperidium already appears thinly membranous. Therefore, the color of the swollen capillitial septa would be the only difference between these two taxa (although according to Wright *–loc.cit.–* even in this point they are equal), which, in our opinion, is not enough in order to maintain two separated species.

Moreover, we must add that it is strange that an European and Mediterranean species like *T.beccarianum* is only known from the holotype; other collections from the same area have not been identified as such. Thus, considering the similarities between this species and *T.simulans*, we propose *T.beccarianum* and *T.simulans* as synonyms. As Bresadola's epithet is older than Lloyd's, *T.beccarianum* has priority in accordance with the article 11 of ICBN, in spite that *T.simulans* is better known and its epithet has been more commonly used. Thus:

Tulostoma beccarianum **Bresad. *in* Petri,** *Ann.Mycol.* 2:413–414 (1904).
= *T.simulans* Lloyd, *The Tylostomeae* p.18, pl.79, figs.2–3 (1906).

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We wish to express our gratitude to Dr. A.Y.Rossman (**BPI**), and also to Dr. Å.Strid and U.Malmgren (**S**), for the loan of the type material of *T.simulans* and *T.beccarianum*, respectively. Thanks are due Dr. J.E.Wright and Dr. F.D.Calonge for the revision of the manuscript and to Dr. F.Esteve–Raventós for revising the English text; likewise to Mr. J.A.Pérez for his collaboration with the SEM.

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MYCOTAXON

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TORRENDIELLA QUINTOCENTENARIA: A NEW QUERCICOLOUS SPECIES FROM MEXICO

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SUMMARY

Torrendiella quintocentenaria Galán & Palmer, sp. nov., collected on oak leaves, is described from Mexico. It is compared with the type species of ***Torrendiella*** Boud. & Torrend, ***T. ciliata*** Boud., exclusively of European distribution, including the Canary Islands, together with new records and microscopical characters not previously considered. In addition, ***Rutstroemia setulata*** (Dearness & House) White is transferred to ***Torrendiella*** as ***T. setulata*** (Dearness & House) Galán & Palmer, comb. nov.

RESUMEN

Se describe ***Torrendiella quintocentenaria*** Galán & Palmer, sp. nov., encontrada en hojas de *Quercus*, procedente de México, al tiempo que se compara con la especie tipo de ***Torrendiella*** Boud. & Torrend, ***T. ciliata*** Boud., de distribución exclusivamente europea, (incluyendo las Islas Canarias), de la que se aportan nuevas citas y se incide en caracteres microscópicos hasta ahora desapercibidos. Finalmente, se transfiere ***Rutstroemia setulata*** (Dearness & House) White a ***Torrendiella***, bajo la denominación de ***T. setulata*** (Dearness & House) Galán & Palmer, comb. nov.

KEY WORDS: ***Rutstroemia***, ***Torrendiella***, ***Zoellneria***, Sclerotiniaceae, ***Quercus***, Canary Islands, Europe, Mexico.

INTRODUCTION

During a short visit to Baja California, Mexico, in March, 1990, for the collection of saprophytic discomycetes (principally Leotiales), when invaluably aided by the two last authors (C.O. and N.A.), the first author (R.G.) had the opportunity to explore this distinctly mediterranean-type area, which bears a close resemblance to the Iberian Peninsula although floristically very different. The groves of ***Quercus agrifolia*** Née proved to be the most favourable, producing a foliicolous species of particular interest, which fruited copiously and which, from its particular aspect and prominent setae, fitted readily into the genus ***Torrendiella*** Boud. (Sclerotiniaceae).

The present work, in collaboration of the first two authors (R.G. and J.T.P.), discusses the results of microscopic study and also considers certain characters traditionally omitted from descriptions of the type species, ***Torrendiella ciliata*** Boud.

METHODS

These have been in accordance with those earlier published (Galán, Honrubia & Palmer, 1988). Apothecia were dried after collection by the first author and, later, after rehydrating in 5% KOH, were sectioned on a freezing microtome ("Erma", Japan) with the sections promptly mounted in Melzer or Lactophenol Blue. Photographs were obtained using a Nikon Labophot-2 model microscope with an automatic photographic system and fitted with a phase contrast attachment. Similar studies by the second author have utilized an Olympus BH-2 microscope, also fitted with a phase contrast attachment.

DESCRIPTION

Torrendiella quintocentenaria Galán & Palmer sp. nov. (***Figs. 1-8***)

Stroma inconspicuum, immersum. **Apothecia** dispersa, erumpentia, longe stipitata, cupulata, 0.7-2 mm in diametro, disco plano, pallide griseo, extus brunnea, fibrillosa, margine longe setosa. **Setae** conicae, radicatae, multiseptatae, crassiter tunicatae, fuscae, 120-310 x 9-16 µm. **Excipulum ectale** tribus tegumentis formatum. Tegumentum externum hyphis fuscis, flexuosis, sparse fasciculatis. Tegumentum medium textura oblita, hyphis hyalinis. Tegumentum internum textura porrecta, hyphis latis (cellulis 24-60 x 7-15 µm), pallide brunneis, tenuiter tunicatis, incrustatis. **Excipulum medullare** textura intricata subhyalina. **Subhymenium** densum textura intricata brunnea. **Asci** subcylindracei, octospori, poro iodo coerulescentia, 114-128 (-140) x 8-10.3(-11) µm. **Ascosporae** uniseriatae, ovoideae, minute inaequilaterales, hyalinae, aseptatae, uniguttulatae, 9.6-13.6 x (5.2-)6.6-8.8 µm. **Paraphyses** cylindraceae

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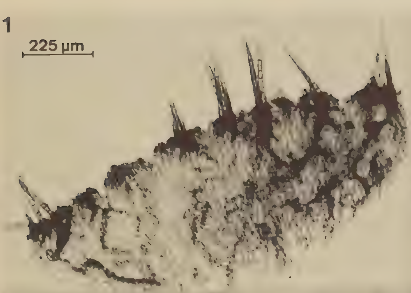
Figs. 1-8.- ***Torrendiella quintocentenaria*** Galán & Palmer (Holotype): ***1.*** Face view of apothecium showing a crenulate margin and groups of setae; ***2 & 3.*** Setae; ***4.*** Longitudinal section of apothecium showing the hymenium (***h***), subhymenium (***sh***), Medullary excipulum (***ME***) and the outer (***oe***), medial (***me***) and internal (***ie***) layer of the Ectal excipulum (***EE***); ***5.*** Asci with amyloid plugs; ***6.*** Encrusted hyphae of the outer layer of the Ectal excipulum; ***7.*** Gelatinized medial layer (***me***) with remarkable lumina of cells and internal layer (***ie***) of the Ectal excipulum near the margin; ***8.*** Oblique section of the apothecium showing the Medullary excipulum (***ME***) and different layers of the Ectal excipulum.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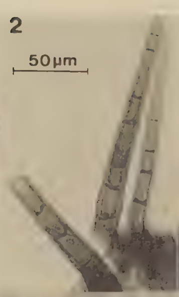
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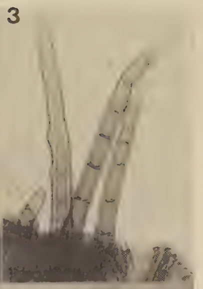
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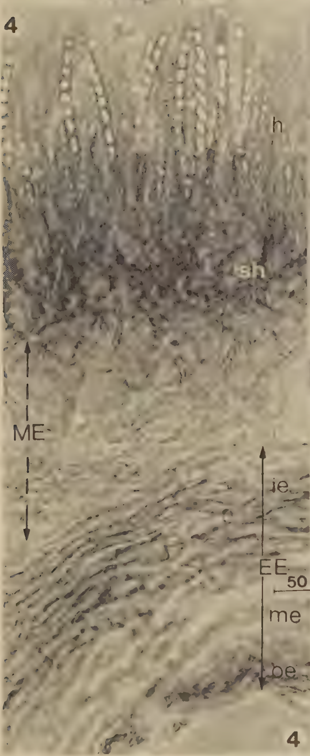
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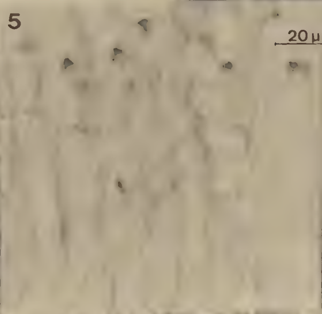
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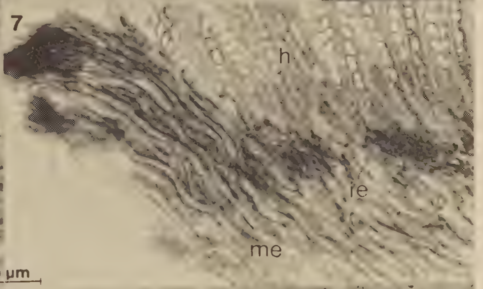
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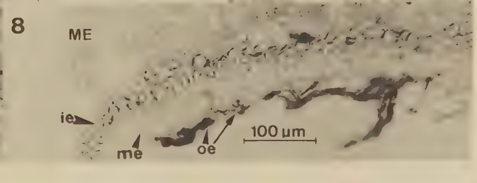
8
ME
ie
me
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100 µm

vel subclavatae, basim ramosae, multiseptatae, ascos minute superantes, 2-4 µm in diametro.

Substratum.- In foliis emortuis ***Quercus agrifoliae*** Née, El Sauzal, Baja California, Mexico; legit C. Ochoa, R. Galán, G. Moreno & N. Ayala (14.III.1990), **Holotypus** in RG 6733, isotypus in JTP 4694 et Herb. CUP.

Stroma inconspicuous, only visible as black lines in the substrate and blackening at the bases of the ascocarps. **Apothecia** scattered, erumpent, distinctly stipitate, cupulate, developing from petioles, veins or leaf parenchyma. **Disc** plane, 0.7-2 mm in diameter, pale greyish when rehydrated. **Receptacle** brownish, covered by decurrent, brown, scattered fibrils and bearing conspicuous setae, arising scattered or, more frequently, in small groups, confined to the margin, which is additionally laciniate ***(Fig. 1)***. **Stipe** concolorous, cylindrical, dark brown, black at the base, equalling or slightly exceeding the diameter of the disc in length, smooth or as fibrillose as the receptacle. **Setae** stiff, simple, conical with a rooted base, pluriseptate, (walls 2-2.5 µm thick), dark brown, shiny, 120-310 µm in length, 9-16 µm diameter near the base, abruptly narrowed below and gradually tapered towards the apex, becoming paler, arising from the outer (?) cells of the excipulum ***(Figs. 2 & 3)***. **Ectal Excipulum** in three layers: outer zone indeterminate, formed of some coalescent rows of flexuous brown hyphae (4-6.5 µm diam.), sometimes with free, obtuse ends, arranged in scattered strands, parallel to the surface and having thin walls encrusted with pigment (giving a banded aspect) ***(Figs. 4, 6 & 8)***. The medial layer (16-20 µm thick) is formed of hyaline, branched hyphae, similarly parallel to the surface, with very narrow lumina and strongly gelatinized walls ***(Figs. 4, 7 & 8)***. The inner zone of imprecise thickness (and gradually merging with the medullary excipulum) is formed of broad, light brown, thin-walled hyphae with encrusted surfaces (individual cells of 24-60 x 7-15 µm) ***(Figs. 4, 7 & 8)***. **Medullary Excipulum** well developed, formed of interwoven subhyaline hyphae (3-7 µm diam.), vertically arranged in the stipe. ***(Figs. 4 & 8)*** **Subhymenium** formed of densely woven, brown, narrow hyphae (textura intricata) ***(Fig. 4)***. **Asci** 8-spored, subcylindrical, progressively attenuated below, with a rounded apex (the pore strongly blue in Melzer's reagent), measuring 114-128 (-140) x 8-10.3 (-11) µm ***(Figs. 4 & 5)***. **Ascospores** uniseriate, hyaline, ovoid, one-celled, slightly inequilateral, uniguttulate, 9.6-13.6 x (5.2-) 6.6-8.8 µm ***(Figs. 5)***. **Paraphyses** cylindrical or subclavate (2-4 µm wide), pluriseptate, branched at the base, scarcely protruding above asci.

Substrate.- On dead, fallen leaves of ***Quercus agrifolia*** Née, on either petioles, veins or parenchyma; near Rancho La Cruz, El Sauzal, Baja California, Mexico; leg. C. Ochoa, R. Galán, G. Moreno & N. Ayala (14.III.1990). **Holotype** in RG 6733, isotypes in JTP 4694 and Herb. CUP.

ETYMOLOGY.- From Latin: **quintocentenaria** - quincentenary of the discovery of America by Cristobal Colón (Christopher Columbus).

OBSERVATIONS

The genus ***Torrendiella*** Boudier et Torrend, 1911, typified with ***T. ciliata*** Boud., described from woody twigs (*'ramilles de bois'*) in Portugal, was ambiguously placed amongst the Hyaloscyphaceae owing to the presence of hairs on the receptacle. It was disinterred by GRADDON (1979), who redescribed the species from England as foliicolous (*'on leaves of* **Rubus***'*) with a stromatic development (*'a narrow black line on the leaf surface rings the area carrying the apothecia...'*) and a gelatinous receptacle (*'Excipulum phialoid, of slender (2-3 µm) threads of septate lumen in a hyaline matrix ...'*), all characters which occur in certain members of the Sclerotiniaceae.

On the other hand, the genus ***Zoellneria*** Velen., 1934, also originally placed in the Hyaloscyphaceae and later typified by DENNIS (1959) with ***Z. rosarum*** Velen., 1934, was considered to have a doubtful position in the Hyaloscyphaceae (DENNIS, 1962; ERIKSSON & HAWKSWORTH, 1987) or the Sclerotiniaceae (RAITVIIR, 1970). On the contrary, it has been been several times suggested as a possible synonym of ***Torrendiella*** (DENNIS, 1978).

SPOONER (1987) indubitably considered ***Torrendiella*** to belong to the Sclerotiniaceae, (which opinion we share, as PDA cultures inoculated by the second author produced stromata), and transferred three species, ***Zoellneria clelandii*** (Hansf.) Dennis, ***Z. eucalypti*** (Berk.) Dennis and ***Z. madseni*** Beaton & Weste to ***Torrendiella***. However, whilst stating that the type species, ***Zoellneria rosarum*** Velen., had a comparable excipular structure, he doubted whether the two genera were congeneric. As we have not studied the type or authentic material of ***Z. rosarum***, we cannot express an opinion.

Torrendiella ciliata is not confined to the type locality (Lisbon, Portugal) and England (GRADDON, op. cit.) but has been several times collected elsewhere by the second author.

In **Portugal:** Minho (JTP 4484 developed subsequently on a leaf of ***Quercus suber*** L.); **Peninsular Spain:** Pontevedra (JTP 4381 = RG 6762 on petioles and JTP 4382 on the parenchyma of ***Q. suber*** leaves), Cáceres (JTP 4488 on midrib of a ***Q. suber*** leaf), Barcelona (JTP 4609 on the petiole of a leaf of ***Quercus ilex*** L.) (GALÁN, 1991), **Balearic Islands:** Menorca (JTP 4615 on petiole of a ***Q. ilex*** leaf); **Canary Islands:** Gomera (JTP 4516 on blade edge of ***Laurus azorica*** (Seub.) Franco leaf) and Tenerife (JTP 4526 on parenchyma of a ***Laurus*** sp. leaf). It has also been found by the first author in **Peninsular Spain:** Huelva (RG 6761 on petiole of a ***Q. suber*** leaf).

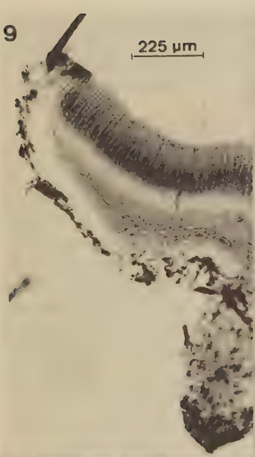
Consequently, after a detailed study of the preceding and duplicates of two further English collections of ***T. ciliata***, made by the late Mr. M. C. Clarke and sent to the second author, we reached the conclusion that SPOONER (op. cit.: 318, 320), when redescribing English material, misinterpreted the construction of the ectal excipulum, i.e. '*Gelatinized tissue is absent ...*' and '*Ectal excipulumm composed of thin- or thick-walled, pigmented, angular to prismatic cells*'). Nevertheless, he further stated that '*the form* *and structure of the apothecia support the suggestion of a close relationship with* **Lanzia** *or* **Rutstroemia** *sensu lato*' (SPOONER op.cit. 318). Such a suggestion supports the first author's view that ***T. ciliata*** could be congeneric with ***Rutstroemia firma*** (Pers.: Fr.) Karst., above all as concerns the microanatomy of the apothecia (***Figs. 9–15***) with a refractive middle layer in both of their ectal excipula, so that only the presence of large, excipular setae in the first of the two cases deviates from this similarity. In addition, he considers that the general resemblance confirms his opinion that the presence or absence of setae is of a secondary nature, which he considers to be a minor character (at the level of a series or subgenus) in ***Rutstroemia***. This point of view is not new when one considers that WHITE (1941) recombined ***Ombrophila setulata*** Dearness & House, whose apothecia are provided with similar setae, in ***Rutstroemia*** as ***R. setulata*** (Dearness & House) White. In a similar manner, VELENOVSKÝ (1934: 229) placed ***R. firma*** in close proximity to ***R. rubi*** Velen., with this last species now considered a synonym of ***T. ciliata*** (SPOONER, op. cit.).

However, it is a fact that ***Rutstroemia***, until the comparatively recent segregation into ***Ciboria***, ***Lanzia*** and ***Poculum*** by DUMONT (1972), with the latter currently considered a synonym of ***Rutstroemia***, was a large and unwieldy genus and, particularly as ***Torrendiella*** remained forgotten until resurrected by GRADDON (1979), the second author considers it would be a retrograde step to place this small group of macroscopically recognizable species in ***Rutstroemia***. Therefore, we describe this Mexican fungus as a new species of ***Torrendiella***.

The apothecia of ***Torrendiella quintocentenaria*** immediately recall ***T. ciliata*** with the same sclerotiniaceous habit, the very prominent, long setae and the apparent preference for a foliicolous habit. However, despite these factors, and after a more careful comparison, new microscopical differences are evident. The margin of ***T. quintocentenaria*** is not entire but minutely crenate with convex or truncate teeth, the setae are not so prominent as in ***T. ciliata***, where they frequently exceed 250 µm, reaching up to 500 µm and are usually restricted to around the margin, not extending to the flank or stipe, and generally appear in small groups, not scattered. The most distinctive feature under the light microscope is the shape of the spores, a valuable diagnostic character, which are ovoid in ***T. quintocentenaria*** against the mostly narrowly reniform ascospores of ***T. ciliata***. Other characters, such as spore, ascal and setal dimensions, contribute to the separation of the two taxa (c.f. ***Figs. 1–15***).

Figs. 9–15.– ***Torrendiella ciliata*** Boud. (RG 6762): ***9.*** Longitudinal section of apothecium; ***10.*** Asci; ***11.*** Gelatinized medial layer (***me***) and internal layer (***ie***) of the Ectal excipulum; ***12*** & ***15.*** Longitudinal sections of apothecia showing the hymenium (***h***), Medullary excipulum (***ME***) and the outer (***oe***), medial (***me***) and internal (***ie***) layers of the Ectal excipulum; ***13.*** Scattered setae arising from flanks; ***14.*** Gelatinized medial layer of the Ectal excipulum with ramified hyphae containing conspicuous lumina.

9



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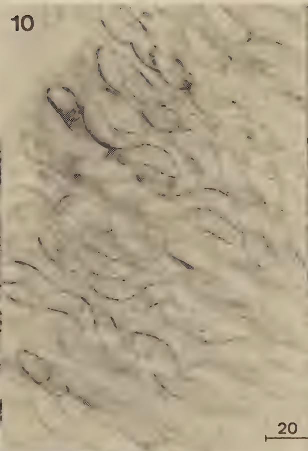

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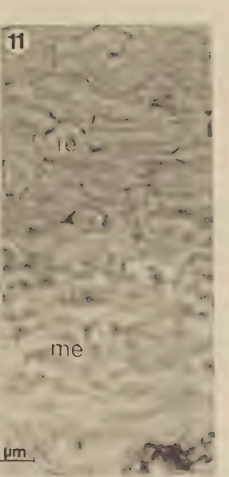

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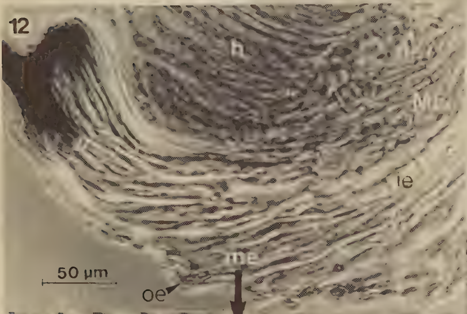
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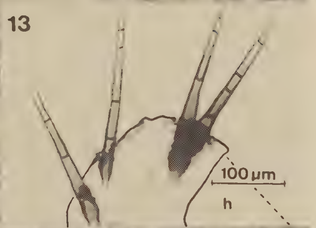

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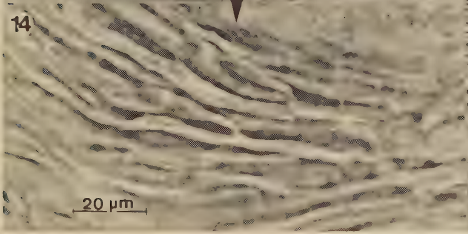

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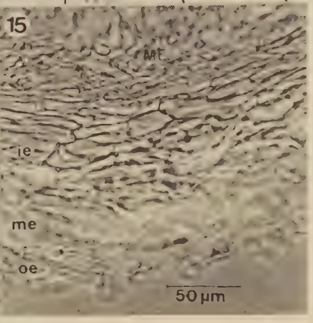
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The microanatomy of the apothecia of *T. quintocentenaria* is, however, indistinguishable from ***Rutstroemia allantospora*** Galán, Honrubia & Palmer (1988) on ***Pinus*** bark in Spain with similar banded hyphae in the receptacle. ***T. ciliata***, on the other hand, lacks this characteristic encrustation whilst the hyphae of the innermost layer are feebly pigmented.

Judging by the description given by WHITE (1941) for ***Rutstroemia setulata*** (Dearness & House) White, ***T. quintocentenaria*** appears to be very similar. Nevertheless, the '*short-celled hyphae, 3-5 µm diameter*', which form the more internal layer of the excipulum, the much shorter setae (60-100 µm), as well as the form and dimensions of the spores ('*narrow ellipsoid, somewhat flattened on one side, 15-19 x 6.5-8 µm, with a large oil globule in each end*') and, above all, the habitat '*on dead twigs of* **Acer spicatum**', differentiate these North American species. From the preceding and a preliminary study of type material, it would appear that this species belongs to the genus ***Torrendiella*** and to which we propose its transfer as

Torrendiella setulata (Dearness & House) Galán & Palmer, comb. nov.

Basionym: ***Ombrophila setulata*** Dearness & House, Bull. N. Y.. State Mus. (№ 266) 1924: 60. (1925).

However, it appears that these may not be the only setose species from North America as KOHN (1982), who reported an apparently similar species '*on dying stem of* **Rubus** *sp.*' from La Gomera, Canary Islands, as ***Poculum* sp. 1385** on account of the scanty material, wrote "*There are perhaps half a dozen or more species that were formerly assigned to* **Rutstroemia** *with similar apothecial structure to this species. Drs. K. P. Dumont and R. P. Korf have had a joint project on these species for many years (pers. comm.), of which only one,* **Rutstroemia setulata** *(Dearness & House) White, appears to have been described. Other species have been collected in the southern U.S., in Mexico, in the neotropics and paleotropics. Whether these can be accommodated in* **Poculum**, *from which they differ mainly in the presence of setae, or constitute a separate genus has not yet been decided.*' She seemed to have been unaware of the genus ***Torrendiella*** with its then single species, ***T. ciliata***, no doubt due to its not then being recognized as belonging to the Sclerotiniaceae.

T. quintocentenaria appears to represent a clear example of a vicariant species related to ***T. ciliata***, which has adapted to occupy a similar ecological niche in mediterranean-bajo-californian areas and, consequently, has co-evolutionized with other species of ***Quercus***.

ACKNOWLEDGEMENTS

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MYCOTAXON

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KILIOPHORA: A NEW GENUS NAME FOR THE HYPHOMYCETE TAXON DANAEA

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The hyphomycete genus **Danaea** Caneva & Rambelli erected in 1981 is illegitimate as the name was taken up in 1793 for the primitive fern endemic to tropical America, **Danaea** Sm. (Marattiaceae). **Kiliophora** gen. nov. is erected to accommodate the hyphomycete taxon with **K. fusispora** sp. nov as the type. A second species, **K. ubiensis** is described as a new combination.

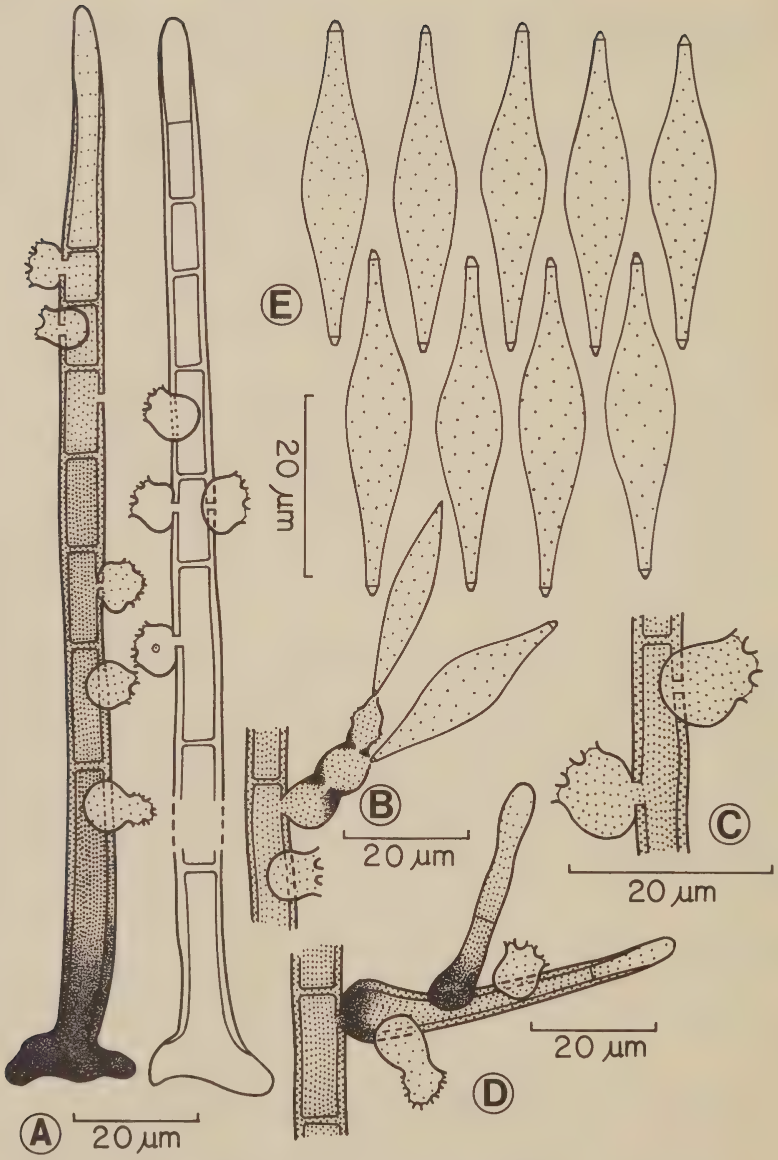
Caneva & Rambelli (1981) erected the hyphomycete genus **Danaea** (spelt as **Danaëa**) with **D. ubiensis** as the type species. The generic name is, however, occupied by the primitive fern endemic to tropical America, **Danaea** Sm. (Mem. Acad. Turin, **5**: 420, 1793; nom. cons. type: **Danaea nodosa** (L.) Sm.; Marattiaceae). The genus **Danaea** for the hyphomycete taxon described by Caneva & Rambelli (1981) is, therefore, illegitimate according to Article 64.1 of the International Code of Botanical Nomenclature. A new genus is introduced to accommodate the hyphomycete taxon.

Kiliophora Kuthub. & Nawawi gen. nov.

Danaëa nom. illeg. Caneva & Rambelli, Micologia Italiana 10: 47 (1981).

(Etym.: 'Kili-kili' (Malay) = spindle and 'phora' (L) = carrier; in reference to the conidiophores bearing spindle shaped conidia).

Coloniae effusae. **Mycelium** plerumque in substrato immersum. **Conidiophora** macronematosa, mononematosa, brunnea, erecta, recta vel leviter flexuosa, simplicia vel exigue ramosa, solitaria, aliquando fasciculata, setiformia, cellula terminalia aliquando fertilia et ad apicem polytretica. **Cellulae**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D
A
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Fig. 1. **Kiliophora fusispora** A. Conidiophores and conidiogenous cells; B & C. Conidiogenous cells; D. Lateral branch on conidiophore. E. Conidia.

conidiogenae in medio conidiophora sitae, enteroblasticae, polytreticae, discretae (nisi in cellulae terminale conidiophorum incorporatae), simpliciae vel proliferae et ramosae, globosae vel lageniformae. **Conidia** acropleurogenosa, sicca, subhyalina vel pallide brunnea, fusiformia.

Species typica: **Kiliophora fusispora**

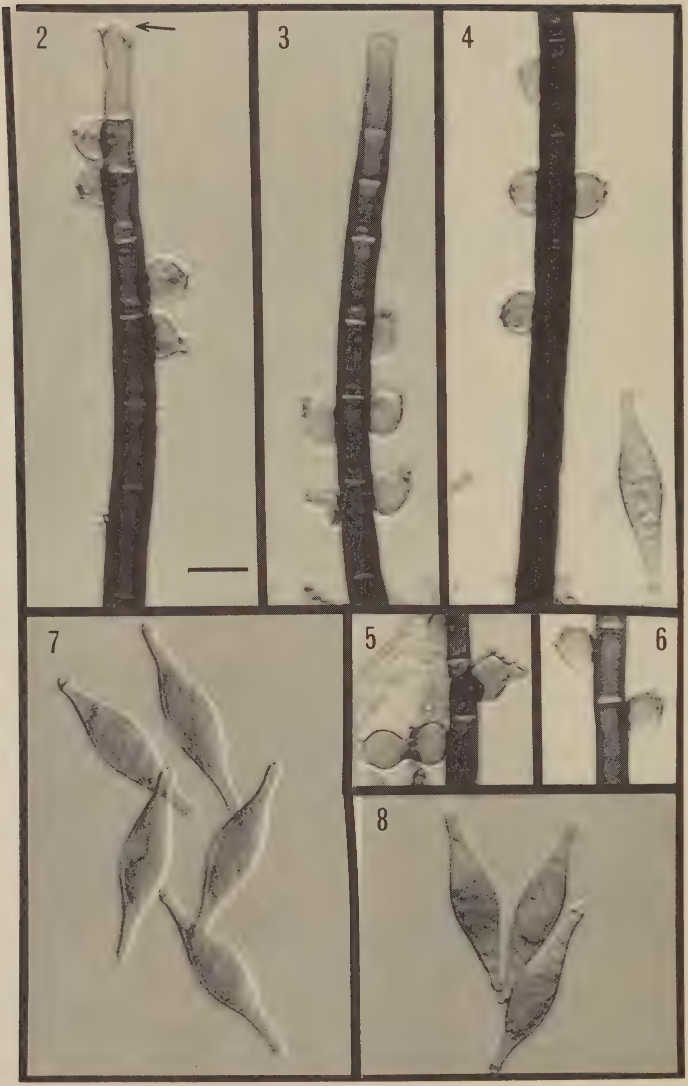
Colonies effuse. **Mycelium** mostly immersed in the substratum. **Conidiophores** macronematous, mononematous, brown, erect, straight or slightly flexuous, simple, sometimes sparingly branched with one or two lateral branches arising about midway up the conidiophores and at the points of emergence of the discrete conidiogenous cells, mostly solitary, occasionally in loose fascicles of 2 - 3, setiform, terminal cell sometimes fertile bearing conidia from polytretic conidiogenous loci at the tip of the cell. **Conidiogenous cells** formed about midway up the conidiophore, enteroblastic, polytretic, discrete and produced through minute pores in the conidiophore (except when incorporated in the terminal end of the setiform conidiophore), simple or proliferating repeatedly through one or more of the conidiogenous loci in the previously formed cell to produce simple or branched chains of conidiogenous cells, globose to broadly lageniform. **Conidia** acropleurogenous, dry, subhyaline to pale brown, fusiform to broadly spindle-shaped.

The genus **Kiliophora** is characterised by the presence of enteroblastic, polytretic, discrete conidiogenous cells arising directly and from about midway up the setiform conidiophores, and sometimes with polytretic conidiogenous cells incorporated in the terminal cells of the conidiophores. Based on these features, **Kiliophora** can be separated from phialidic taxa such as **Chaetopsina** Rambelli, **Chaetopsis** Greville, and **Zanclospora** Hughes & Kendrick and from the polyblastic genus **Spondylocladiopsis** Ellis.

Kiliophora fusispora Kuthub. & Nawawi sp. nov.

(Figs. 1 - 8)

Coloniae effusae. **Mycelium** in substrato immersum, ex hyphis laevis, septatis, pallide brunneis vel brunneis, ramosis, 2 - 4 µm latis compositum. **Conidiophora** macronematosa, mononematosa, laevia, ad basim fusca, ad apicem pallida, erecta, crassitunicata, setiformia, septata, simplicia, solitaria, usque ad 200 µm alta, attenuata, ad basim 6 - 9 µm lata, ad apicem 4 - 6 µm lata et fertilia. **Cellulae conidiogenae** in medio conidiophoro



Figs. 2 - 8. **Kiliophora fusispora.** Figs. 2 - 4. Conidiophores; fertile tip of conidiophore arrowed; Figs. 5 - 6. Conidiogenous cells; Figs. 7 - 8. Conidia. All figures to the same scale, bar = 10 μm.

sitae, enteroblasticae, polytreticae, discretae, subhyalinae vel pallide brunneae, simpliciae, globosae vel subglobosae, 6 - 9 µm wide. Conidia acropleurogenosa, subhyalina vel pallide brunnea, laevia, aseptata, fusiformia, 30 - 37 µm longa, 6 - 8 µm lata, ad extremibus attenuata, 2 - 2.5 µm lata.

In foliis emortuis angiospermae ignota, Danum Forest Reserve, Sarawak, Malaysia, A.J. Kuthubutheen, June 1989, IMI 355816, holotypus.

Colonies effuse. **Mycelium** immersed in the substratum, composed of smooth, septate, pale brown to brown, branched hyphae 2 - 4 µm wide. **Conidiophores** macronematous, mononematous, smooth, dark brown toward the base, paler above, erect, thick-walled, setiform, septate, simple, solitary, up to 200 µm long, 6 - 9 µm wide toward the base, gradually attentuated to 4 - 6 µm wide toward the apex, terminal cell polytretic and fertile. **Conidiogenous cells** formed about midway up the conidiophores, enteroblastic, polytretic, discrete and produced through minute pores in the conidiophore (except when incorporated in the terminal cell of the setiform conidiophore), subhyaline to pale brown, simple but occasionally proliferating through one or more of the conidiogenous loci in the previously formed conidiogenous cell, globose to subglobose, 6 - 9 µm wide. **Conidia** acropleurogenous, subhyaline to pale brown, smooth, simple, solitary, aseptate, fusiform, 30 - 37 µm long, 6 - 8 µm wide at the broadest point, attenuated toward both ends to be 2 - 2.5 µm wide. Both ends of the conidia have denticle-like projections and appear morphologically similar.

Other specimen examined: On decaying submerged leaves, Rengit Forest Reserve, Pahang, Malaysia, A.J. Kuthubutheen, September 1991, University of Malaya Herbarium KLU 300024.

Kiliophora ubiensis (Caneva & Rambelli) Kuthub. & Nawawi comb. nov.

Danaea ubiensis Caneva & Rambelli, **Micologia Italiana 10:** 47 (1981)

(Figs. 9 - 14)

Colonies effuse. **Mycelium** mostly immersed in substratum, comprised of smooth, septate, pale brown to brown, branched hyphae 2 - 4 µm wide. **Conidiophores** macronematous, mononematous, smooth, dark brown toward the base, becoming paler toward the apex, erect, thick-walled, setiform, septate, up to 200 µm long, 5 - 7 µm wide toward the base, becoming gradually attenuated and 3 - 4 µm wide toward the rounded apex,

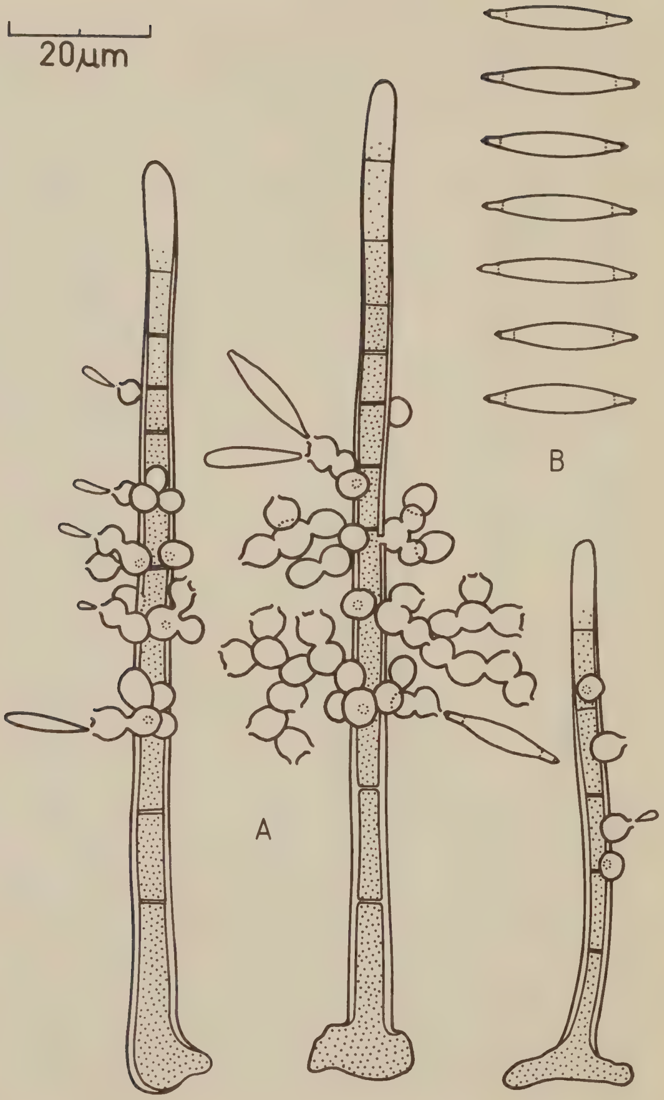


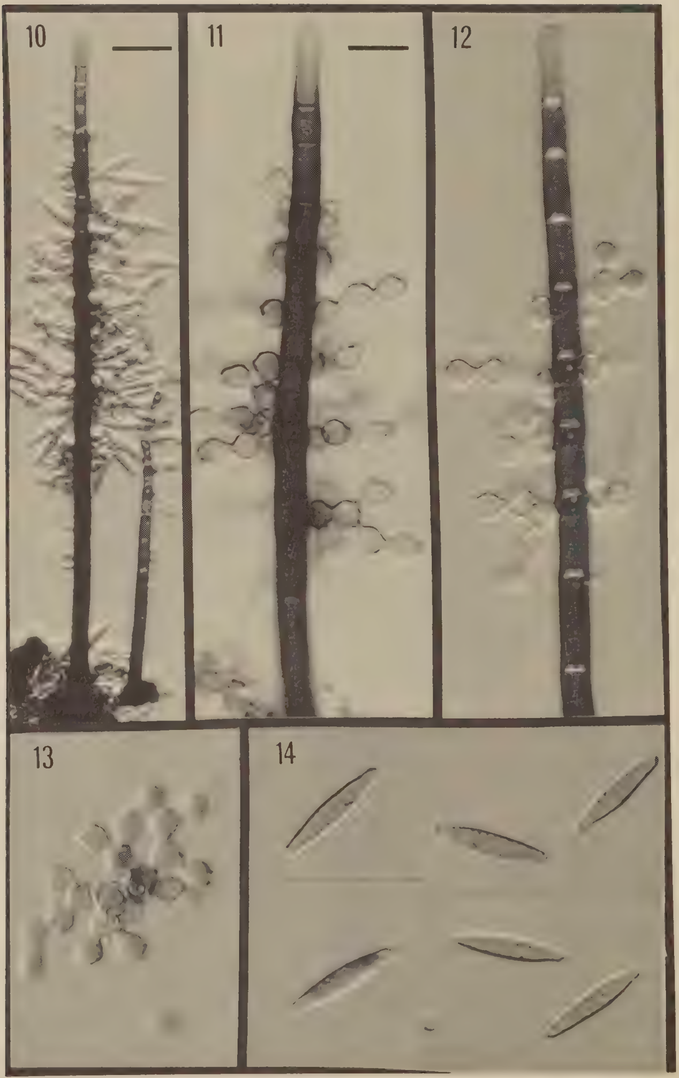
Fig. 9. **Kiliophora ubiensis.** A. Conidiophores with conidiogenous cells proliferating to form chains. B. Conidia.

mostly simple, occasionally sparingly branched with one or two lateral branches up to 40 µm long, 3 - 4 µm wide arising at the points of emergence of the discrete conidiogenous cells, mostly solitary, sometimes in loose fascicles of 2 - 3. **Conidiogenous cells** formed about midway up and through minute pores in the conidiophores, enteroblastic, polytretic, discrete, subhyaline, globose to subglobose, 4 - 6 µm wide, smooth, initially simple and solitary, then proliferating repeatedly through one or more of the conidiogenous loci in the previously formed cell to produce branched chains of conidiogenous cells. **Conidia** acropleurogenous, subhyaline, pale greyish brown in mass, smooth, simple, solitary, aseptate, fusiform, 18 - 25 µm long, 3 - 5 µm wide at the broadest point. Both ends of the conidia have denticle-like projections and appear morphologically similar.

Specimens examined: On decaying leaves, Forest Research Institute, Kepong, Selangor, Malaysia, A.J. Kuthubutheen, June 1985, IMI 355817; on decaying leaves, Gua Musang, Kelantan, Malaysia, A.J. Kuthubutheen, February 1989, KLU 300010; on decaying submerged leaves, Danum Forest Reserve, Sabah, Malaysia, A.J. Kuthubutheen, June 1989, KLU 300011; on decaying submerged leaves, Rengit Forest Reserve, Pahang, Malaysia, A.J. Kuthubutheen, September 1991, KLU 300025; on decaying leaves, Pasuh Forest Reserve, Negeri Sembilan, Malaysia, A. Nawawi, 16.6.1987, KLU 300012; on decaying leaves, Forest Reserve Brunei, Brunei, A. Nawawi, 18.8.1988, KLU 300013.

The setiform conidiophores of **K. fusispora** are somewhat broader than those of **K. ubiensis.** In the former, the terminal cell sometimes becomes fertile and 3 - 4 tretic conidiogenous loci may be formed at the tip of the conidiophore. Although the conidiogenous cells of **K. fusispora** do occasionally proliferate, the repeatedly branched chains of conidiogenous cells present in **K. ubiensis** do not develop even in moist chambers. The conidiogenous cells of **K. fusispora** are larger than those of **K. ubiensis.** Amongst the most striking differences between the two species is the conidial shape and dimensions. In **K. fusispora** the conidium is markedly attenuated towards both ends which are narrower compared to the main body of the conidium. The conidia of **K. ubiensis** are much shorter and narrower than those of **K. fusispora.** The peculiar denticle-like projections at both ends of the conidia are found in the two species.

The conidiophore morphology, conidiogenesis and conidial characteristics of **K. ubiensis** from Malaysia and from the Ivory Coast (Caneva & Rambelli, 1981) are similar. The major difference is the proliferation of conidiogenous cells to produce



Figs. 10 - 14. **Kiliophora ubiensis.** Figs. 10 - 12. Conidiophores with chains of conidiogenous cells; Fig. 13. Conidiogenous cells; Fig. 14 Conidia. Fig. 10 bar = 20 µm. Figs. 11 - 14 to same scale, bar = 10 µm.

branched chains observed in the Malaysian isolates. This feature is particularly common on leaves incubated in moist chambers. In the Malaysian isolates, solitary conidiogenous cells are not uncommon and all chains start off initially from solitary cells. In view of these observations, the presence of branched chains of conidiogenous cells is regarded as not significant, at least at species level, to warrant the separation of the Ivory Coast and Malaysian isolates into separate taxa.

Acknowledgements: The authors are grateful to Dr. Eric McKenzie, Landcare Research, Auckland, New Zealand for pre-submission review of this paper; Dr. Haji Mohamed, the bryologist at the Department of Botany, for drawing our attention to the fern genus **Danaea;** the Malaysian National Science Council for the R & D Grant (01-07-04-15) to undertake the study of Malaysian microfungi; and Mr. Kamaruddin Md. Isa for technical assistance in the field.

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THE LICHEN FLORA OF COASTAL AND INLAND AREAS IN THE GODTHÅB FJORD AND THE AMERALIK FJORD, SOUTHWESTERN GREENLAND

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SUMMARY

The lichen flora of Nuuk, Qornoq and Kapisigdlit in the Godthåb fjord and Qasigiánguit in the Ameralik fjord, southwestern Greenland, is described on the basis of 970 specimens of 237 species and 4 subspecies and varieties collected by the author in the summer of 1990. Information is given about climate, topography, geology and the most important types of lichen vegetation. All lichens collected are listed alphabetically. The inland regions have a somewhat richer flora than the coastal region and are also more rich in lichens with a distinct preference for continental areas in Greenland.

INTRODUCTION

All of the four areas, whose flora and vegetation is dealt with in the present paper, are situated in the northwestern part of Nuuk municipality. The whole region can be considered rich in lichens (Branth & Grønlund 1888; Dahl 1950; Böcher 1954), although it is definitely so that only very few localities have been completely investigated previously.

The earliest known plant collectors in the Godthåb district are the Danish missionary Hans Egede and particularly his son Paul Egede, who collected a "Herbarium Vivum" dated 1739. It is the oldest collection of Greenland plants deposited at the Botanical Museum, University of Copenhagen.

In the years 1828-36 the Danish botanist Jens Vahl made very extensive collections of plants including lichens and mosses along the whole west coast of Greenland. He visited the Godthåb district in 1830-32 and collected lichens very diligently in, for example, the Ameralik fjord. His finds were published by Fries (1860), Nylander (1862) and more widely by Branth & Grønlund (1888). Dahl (1950) has revised a large part of the macrolichens collected by Jens Vahl.

Heinrich Rink, factor and later director of KGH, collected many plants during his travels in Greenland 1848-68. Many lichens from Nuuk collected by him are kept in herb. C. Dahl (1950) has published Rink's macrolichens from this area.

In 1871 the Swedish professor Thore Magnus Fries collected lichens in Nuuk. They were published by Lynge (1937).

During the last thirty years of the nineteenth century some comparatively small collections of lichens were made in the Godthåb district by Andreas Kornerup, Eugenius Warming, L. Kolderup Rosenvinge and Nikolaj Hartz (Dahl 1950).

After a long pause there were great lichenological activity again in the Godthåb district in 1946, when the the two Danish botanists Mogens Skytte Christiansen and Tyge Böcher collected lichens here in connection with their general vegetation studies in southwestern Greenland (Böcher 1954).

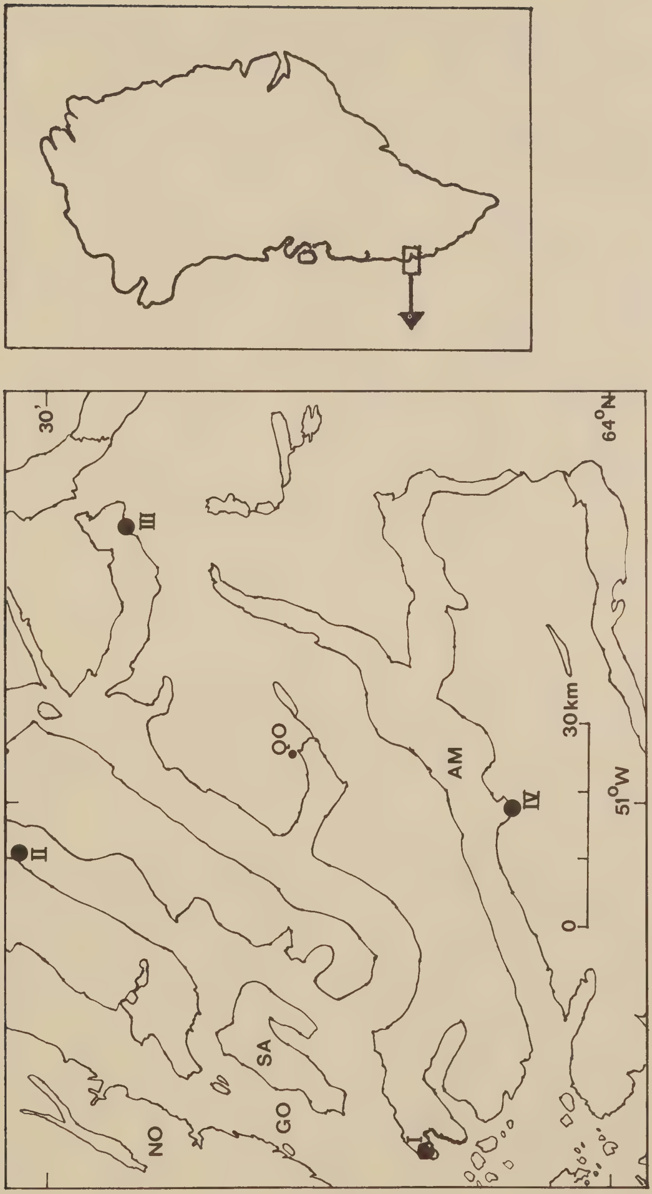
In 1976 Vagn Alstrup collected lichens in the Godthåb fjord area (Alstrup 1977, 1979, 1986).

The present author visited this area in July and early August 1990. The collected lichen material is deposited at the Botanical Museum, University of Copenhagen.

VISITED LOCALITIES

1. Nuuk (64°10'N, 51°43'W), the capital of Greenland, is located outermost on the west coast of a peninsula, c. 25 km from the entrance of the Godthåb fjord (Fig. 1). The town was founded in 1728, by the time that Hans Egede moved from Håbets ø to a better protected place with greater potential resources. In 1950 Nuuk had 1000 inhabitants, today c. 13000 after a population explosion partly due to lowered mortality and partly because of the policy of population concentration. About 5000 of Nuuk's inhabitants live in the suburb Nuussuaq, which is located between Nuuk's airport, opened in 1979, and the Atlantic harbour. Despite this rapid expansion with development of many types of trades and (mainly smaller) industries and a correspondingly increased traffic, a number of comparatively undisturbed areas with an interesting vegetation still can be found, both within and along the periphery of the town (E. S. Hansen 1991). Sites with undisturbed vegetation are found on some rocky hills, but in particular on the two mountains, Lille Malene (alt. 430 m a.s.l.) and Store Malene (alt. 780 m a.s.l.) situated just to the east of Nuuk.

Fig. 1. The Godthåb fjord area showing the four investigated localities and the most important surroundings. I, Nuuk; II, Qornoq; III, Kapisigdlit; IV, Qasigiánguit; GO, the Godthåb fjord; AM, the Ameralik fjord; NO, Nordlandet; SA, Sadelø; QO, Qoorqut. The small map to the left shows the location of the Godthåb fjord area in Greenland.


30'
III
II
QO
AM
IV
30km
0
51°W
64°N
SA
NO
GO
I

2. Qornoq (64°32'N, 51°06'W), a 1 km long and rather flat island, is situated in the middle of the Godthåb fjord, northeast of Nuuk. Most of the houses of the previous settlement were abandoned c. twenty years ago. Now the island acts as a place of sojourn for young people during summer, but the earlier main activities, drying and transport of cods, have greatly influenced the lichen vegetation.

3. Kapisigdlit (64°26'N, 50°15'W), a settlement with c. 140 inhabitants, is located in the inner part of Kapisigdlit kangerdluat, a fjord belonging to the large Godthåb fjord system. The distance to Nuuk is about 100 km. The village lies at the foot of a rocky hill named Pingo (alt. 470 m a.s.l.). East of Pingo, a broad valley with a system of lakes extends to the south. These lakes and the stream that connects them (Kapisilik) are the only spawninggrounds for salmon in Greenland. The main industries of Kapisigdlit are fishing and domesticated reindeer-breeding.

4. Qasigiánguit (64°04'N, 51°02'W) is a point located at a small bay on the southern coast of the Ameralik fjord. The distance to Nuuk is about 40 km. The bay is bordered by an up to 2 km broad lowland zone, which again is backed by low angle rocky slopes. The landscape is cut by a few glacial streams. The vegetation is to much lesser extent disturbed by man than around the three above-mentioned towns.

CLIMATE

The vegetation pattern of southwestern Greenland and the distribution of species vary not only with latitude, but also with the distance from the outer coast. The climate at the entrance of the Godthåb fjord is influenced by the relatively warm West Greenland current (E. S. Hansen 1978a).

Nuuk's climate falls within the low arctic, oceanic regime characterized by comparatively mild winters, cool summers and an annual precipitation above 500 mm (Dahl 1950; Böcher 1954). The monthly mean of the average temperatures for Nuuk is shown in Table 1. The mean temperature of the warmest month, July, is 7.6°C. The annual temperature amplitude is 15.3°C. However, summer temperatures above 20°C and winter temperatures down to c. -30°C can occur. Nuuk is influenced both by fairly dry winds from the inland ice and by winds from the sea, which carry precipitation, totally 515 mm per year. At Nuuk the snow cover is comparatively thick during winter and early spring. Snow-depth is smaller at the inland localities with exception of north-facing sites.

Table 1. Monthly mean of air temperature (°C) and precipitation (mm) at Nuuk. See Petersen & Staffeldt (1978).

	Max. temp.	Min. temp.	Mean temp.	Prec.
January	12.0	-25.2	-7.7	26
February	11.6	-26.0	-7.3	24
March	14.2	-25.2	-5.8	18
April	13.4	-22.0	-3.5	25
May	18.5	-17.8	2.1	29
June	23.0	-4.3	5.7	46
July	20.2	-6.0	7.6	59
August	19.0	-5.2	6.9	69
September	20.4	-7.4	4.1	84
October	13.8	-13.9	-0.3	71
November	12.0	-16.0	-3.6	44
December	12.2	-23.0	-6.2	20
Year	23.0	-26.0	-0.7	515

Only a sparse meteorological information is available from Qornoq. According to Böcher (1954) this locality has a low arctic, suboceanic climate. The annual range of temperature is 18°C, and the mean temperature of July is 10°C indicating a warmer climate than Nuuk. The annual precipitation is c. 430 mm. During winter the winds come from the east, in summer particularly from the west, carrying moist air.

Recent climatic information from Kapisigdlit is scanty, but it distincly indicates that this settlement has a low arctic, subcontinental (-continental) climate. The annual precipitation is probably between 300-400 mm and and the annual range of temperature is 20°C (Böcher 1954). The mean temperature of January and June is -8.3°C and 8.6°C, respectively. According to Böcher, the inner part of the Godthåb fjord approach closely to really continental climatic conditions. Information about the climate of Qasigiánguit is totally lacking, but presumably it is subcontinental and comparable with that of Kapisigdlit, although somewhat moister.

GEOLOGY

Nuuk is a town built on the oldest fundament in the world, viz. the c. 3040 million years old quartzo-feldspathic Nuuk gneiss (Escher & Stuart Watt 1976). Enclaves of supracrustal rocks, mainly different amphibolites, occur at many sites in and around the town, and basic dykes intersect the gneisses, too. The mountain, Lille Malene, is mainly composed of Amiitsoq gneiss, which is at least 3750 million years old. Layered amphibolites of metabasaltic composition and ironstones are locally abundant. Store Malene mainly consists of Nuuk gneiss. Different types of altered sedimentary and volcanic rocks can also be found, for example, on the top of the mountain. The distribution of gneisses and amphibolites within the Nuuk area and the outermost part of the Ameralik fjord, including Qasigiánguit, can be seen on a geological map (scale 1:100000) published by the Geological Survey of Greenland. (Jensen et al. 1986). Petersen & Secher (1985) summarize the different particular mineral deposits occurring in the Godthåb fjord area, for example, anthophyllit, fuchsit, molybdenit, the wolfram-bearing scheelit and the radioactive minerals, uraninit and uranothorit.

The geology of Qornoq is rather simple: it mainly consists of Nuuk gneiss, which in some places is covered by rusty-red iron-containing minerals. Strongly quartziferous rocks occur scattered on the island, and a few basic rocks are also found.

The eastern part of the bay at Qasigiánguit is composed of Nuuk gneiss with fragments of leucogabbro and anorthosite, while Amiitsoq gneiss (with amphibolite) dominates at the western part of the bay.

Amiitsoq gneiss is the most important type of rock in the area between Kapisigdlit and Kapisilik river. It is separated from the extensive occurrence of Nuuk gneiss south of Kapisigdlit by a narrow zone of +/- Ca-rich amphibolite, which influence the south-facing slopes of Pingo.

LIST OF LICHENS

The lichen species are listed alphabetically on the basis of my collections. The list shows in which areas each of the 241 taxa of lichens was collected (Fig. 1). Some of the lichens were identified in the field, but many specimens were specifically collected for precise identification in the laboratory. Nomenclature follows Santesson (1984) with subsequent changes. The following abbreviations are used: ap. = apothecia present; pe. = perithecia present; st. = sterile specimen. I = Nuuk; II = Qornoq; III = Kapisigdlit; IV = Qasigiánguit.

Acarospora molybdina (Wahlenb. in Ach.) Massal. II(ap.);III(ap.)
A. peliocypha Th. Fr. IV(ap.)
A. sinopica (Wahlenb. in Ach.) Körber III(ap.);IV(ap.)
A. smaragdula (Wahlenb. in Ach.) Massal. II(ap.)
Alectoria nigricans (Ach.) Nyl. I(st.);II(st.);III(st.);IV(st.)
A. ochroleuca (Hoffm.) Massal. I(st.);III(st.);IV(st.)
A. sarmentosa (Ach.) Ach. ssp. vexillifera (Nyl.) D.Hawksw. I(st.);III(st.)
Allantoparmelia alpicola (Th. Fr.) Essl. I(st.);II(st.);III(ap.);IV(st.)
Amygdalaria panaeola (Ach.) Hertel & Brodo I(st.);III(st.);IV(st.)

Arctomia delicatula Th. Fr. I(ap.)
Arthopyrenia sublitoralis (Leight.) Arn. I(pe.)
Arthrorhaphis citrinella Th. Fr. I(st.);II(st.);III(ap.)
Aspicilia caesiocinerea (Nyl. ex Malbr.) Arn. I(ap.); III(ap.);IV(ap.)
A. cinerea (L.) Körber III(ap.)
A. mastrucata (Wahlenb.) Th. Fr. I(ap.);II(ap.);III(ap.); IV(st.)
Baeomyces roseus Pers. I(st.);III(st.)
B. rufus (Huds.) Rebent. I(st.);III(st.);IV(ap.)
Bellemerea cinereorufescens (Ach.) Clauz. & Roux II(ap.); IV(ap.)
Brodoa oroarctica (Brodo) Goward II(st.);III(st.)
Bryocaulon divergens (Ach.) Kärnef. I(st.);II(st.);III(st.) IV(st.)
Bryonora pruinosa (Th. Fr.) Holt.-Hartw. I(ap.)
Bryoria chalybeiformis (L.) Brodo & D.Hawksw. I(st.); II(st.);III(st.);IV(st.)
B. nitidula (Th.Fr.) Brodo & D.Hawksw. IV(st.)
Buellia coniops (Wahlenb. in Ach.) Th. Fr. I(ap.);II(ap.); III(ap.)
Caloplaca alcarum Poelt I(ap.);II(ap.);III(ap.)
C. cerina (Ehrh.) Th. Fr. I(ap.)
C. epithallina Lynge III(ap.)
C. fraudans (Th. Fr.) Oliv. I(ap.)
C. jungermanniae (Vahl) Th. Fr. III(ap.)
C. lithophila Magnusson III(ap.)
C. magni-filii Poelt II(ap.)
C. nivalis (Körber) Th. Fr. I(ap.);IV(ap.)
C. scopularis (Nyl.) Lettau I(ap.)
C. tetraspora (Nyl.) Oliv. I(ap.)
C. tiroliensis Zahlbr. II(ap.)
Candelariella arctica (Körber) R. Sant. I(ap.);II(ap.); III(ap.);IV(ap.)
C. athallina (Wedd.) Du Rietz III(ap.)
C. placodizans (Nyl.) Magnusson I(ap.)
C. vitellina (Hoffm.) Müll. Arg. I(ap.);II(ap.);III(ap.); IV(ap.)
Catapyrenium cinereum (Pers.) Körber III(pe.)
C. lachneum (Ach.) R. Sant. III(pe.)
Cetraria andrejevii Oxner I(st.);II(st.);III(st.);IV(st.)
C. cucullata (Bell.) Ach. I(st.);II(st.);III(st.);IV(st.)
C. delisei (Bory ex Schaerer) Nyl. I(st.);II(st.);IV(ap.)
C. hepatizon (Ach.) Vainio I(st.);II(ap.);III(st.);IV(ap.)
C. islandica (L.) Ach. I(st.);II(st.);III(st.);IV(st.)
C. nigricans Nyl. II(st.);III(st.);IV(st.)
C. nivalis (L.) Ach. I(ap.);II(st.);III(st.);IV(st.)
C. pinastri (Scop.) S. F. Gray III(st.);IV(st.)
C. sepincola (Ehrh.) Ach. III(ap.);IV(ap.)
Cladina mitis (Sandst.) Hustich I(st.);II(st.);III(st.); IV(st.)
C. rangiferina (L.) Nyl. I(st.);II(st.);III(st.);IV(st.)
C. stellaris (Opiz) Brodo I(st.);II(st.);III(st.);IV(st.)
Cladonia amaurocraea (Flörke) Schaerer I(st.);II(st.); III(ap.);IV(st.)
C. bellidiflora (Ach.) Schaerer I(ap.);II(st.);III(ap.); IV(ap.)

C. borealis Stenroos I(st.);II(st.);III(ap.);IV(ap.)
C. carneola (Fr.) Fr. I(st.);III(ap.);IV(ap.)
C. cenotea (Ach.) Schaerer III(st.);IV(st.)
C. cervicornis (Ach.) Flot. ssp. verticillata (Hoffm.) Ahti I(st.);II(st.)
C. chlorophaea (Flörke ex Sommerf.) Sprengel I(st.); II(st.);III(st.);IV(st.)
C. cornuta (L.) Hoffm. ssp. groenlandica (E. Dahl) Ahti III(st.);IV(st.)
C. crispata (Ach.) Flot. I(ap.);II(st.);III(st.);IV(st.)
C. cyanipes (Sommerf.) Nyl. II(st.);III(st.);IV(st.)
C. ecmocyna Leight. I(ap.);III(st.);IV(ap.)
C. fimbriata (L.) Fr. I(st.);II(st.);IV(st.)
C. floerkeana (Fr.) Flörke I(ap.)
C. gracilis (L.) Willd. I(ap.);III(ap.);IV(ap.)
C. luteoalba A. Wils. & Wheld. I(st.)
C. macrophylla (Schaerer) Stenh. I(st.);II(st.);III(ap.); IV(ap.)
C. pleurota (Flörke) Schaerer I(st.);II(st.);III(ap.); IV(ap.)
C. pyxidata (L.) Hoffm. I(ap.);II(st.);III(st.);IV(st.)
C. squamosa (Scop.) Hoffm. I(ap.);III(st.);IV(st.)
C. stricta (Nyl.) Nyl. I(st.);IV(st.)
C. subfurcata (Nyl.) Arn. III(st.)
C. sulphurina (Michx.) Fr. I(st.);II(st.);III(st.);IV(st.)
C. uncialis (L.) Wigg. I(st.);III(st.);IV(st.)
Coelocaulon aculeatum (Schreb.) Link I(st.)
C. muricatum (Ach.) Kärnefelt I(st.);II(st.)
Coniocybe furfuracea (L.) Ach. III(ap.);IV(ap.)
Cystocoleus ebeneus (Dillw.) Thwaites III(st.)
Dactylina arctica (Richardson) Nyl. III(st.);IV(st.)
Dimelaena oreina (Ach.) Norman III(ap.)
Diploschistes scruposus (Schreb.) Norman IV(st.)
Ephebe lanata (L.) Vainio I(st.);IV(st.)
Haematomma ventosum L.) Massal. I(ap.);II(ap.);III(ap.); IV(ap.)
Hymenelia lacustris (With.) Poelt & Vĕzda I(ap.)
Hypogymnia austerodea (Nyl.) Räsänen III(st.)
H. physodes (L.) Nyl. I(st.);III(st.)
H. subobscura (Vainio) Poelt III(st.)
Icmadophila ericetorum (L.) Zahlbr. III(ap.);IV(IV(ap.)
Lasallia pensylvanica (Hoffm.) Llano III(ap.)
Lecanora argopholis (Ach.) Ach. II(ap.);IV(ap.)
L. atrosulphurea (Wahlenb.) Ach. I(ap.)
L. cenisia Ach. III(ap.)
L. chloroleprosa (Vainio) H. Magn. III(st.);IV(st.)
L. contractula Nyl. I(ap.);II(ap.);III(ap.)
L. dispersa (Pers.) Sommerf. II(ap.);III(ap.)
L. fuscescens (Sommerf.) Nyl. in Norrlin II(ap.);III(ap.)
L. intricata (Ach.) Ach I(ap.);II(ap.);III(ap.);IV(ap.)
L. leptacina Sommerf. I(ap.);IV(ap.)
L. polytropa (Hoffm.) Rabenh. I(ap.);II(ap.);III(ap.); IV(ap.)
L. reagens Norman III(st.)
L. straminea Ach. I(st.);II(ap.);III(st.)
L. symmicta (Ach.) Ach. III(ap.);IV(ap.)
Lecidea atrobrunnea (DC.) Schaerer I(ap.)

L. atrofulva Sommerf. I(st.);II(st.);IV(st.)
L. auriculata Th. Fr. II(ap.);IV(ap.)
L. lactea Flörke ex Schaerer I(ap.);II(ap.);III(ap.)
L. lapicida (Ach.) Ach. I(ap.)
L. limosa Ach. I(ap.)
L. marginata Schaerer I(ap.);III(ap.)
L. silacea (Ach.) Ach. IV(ap.)
L. vernalis (L.) Ach. I(ap.);III(ap.);IV(ap.)
Lecidella euphorea (Flörke) Hertel in D. Hawksw. III(ap.)
Lecidoma demissum (Rutstr.) G. Schneider & Hertel I(ap.); II(ap.)
Lepraria arctica (Lynge) Wetmore I;III
L. neglecta (Nyl.) Lettau I;II;III;IV
Leprocaulon subalbicans (Lamb) Lamb & Ward I;II;III
Leptogium lichenoides (L.) Zahlbr. III(st.)
L. saturninum (Dickson) Nyl. III(st.)
Lobaria scrobiculata (Scop.) DC. III(st.)
Massalongia carnosa (Dickson) Körber I(st.);III(st.)
Micarea assimilata (Nyl.) Coppins I(ap.)
Miriquidica nigroleprosa (Vainio) Hertel & Rambold I(ap.); III(st.);IV(st.)
Nephroma arcticum (L.) Torss. I(st.);II(st.);III(st.); IV(st.)
N. expallidum (Nyl.) Nyl. III(st.)
N. parile (Ach.) Ach. III(st.)
Ochrolechia androgyna (Hoffm.) Arn. I(st.)
O. frigida (Sw.) Lynge I(ap.);II(ap.);III(ap.);IV(ap.)
O. geminipara (Th. Fr.) Vainio III(st.);IV(st.)
O. grimmiae Lynge I(ap.)
O. lapuënsis (Vainio in Räsänen) Räsänen I(st.);III(st.); IV(st.)
O. tartarea (L.) Massal. I(st.);II(st.)
O. upsaliensis (L.) Massal. III(ap.)
Omphalina hudsoniana (Jenn.) H. E. Bigelow I;III;IV
O. luteovitellina (Pilát & Nannf.) M. Lange I;II;III;IV
Orphniospora moriopsis (Massal.) D. Hawksw. I(ap.);II(ap.); III(ap.);IV(ap.)
Pannaria pezizoides (Web.) Trevis. I(ap.)
Parmelia centrifuga (L.) Ach. I(st.);II(st.);III(st.); IV(st.)
P. disjuncta Erichsen I(st.);III(st.)
P. fraudans (Nyl.) Nyl. I(st.);III(st.);IV(st.)
P. incurva (Pers.) Fr. I(st.);II(st.);III(st.);IV(st.)
P. infumata Nyl. I(st.)
P. omphalodes (L.) Ach. I(st.);III(ap.);IV(st.)
P. saxatilis (L.) Ach. I(st.);II(st.);III(st.);IV(st.)
P. septentrionalis (Lynge) Ahti III(ap.);IV(ap.)
P. sulcata Taylor I(st.);II(st.);III(st.);IV(st.)
Parmeliella triptophylla (Ach.) Müll. Arg. I(st.)
Parmeliopsis ambigua (Wulf.) Nyl. III(st.);IV(st.)
P. hyperopta (Ach.) Arn. IV(st.)
Peltigera aphthosa (L.) Willd. s. lat. I(st.);II(st.); III(st.);IV(st.)
P. canina (L.) Willd. III(st.)
P. collina (Ach.) Schrad. III(st.)
P. didactyla (With.) Laundon I(st.);II(st.);III(st.); IV(st.)

P. kristinssonii Vitik. IV(st.)
P. malacea (Ach.) Funck I(ap.);II(st.);III(ap.);IV(st.)
P. polydactyla (Neck.) Hoffm. s. lat. III(st.)
P. rufescens (Weis) Humb. I(st.);II(st.);III(ap.)
P. scabrosa Th. Fr. I(ap.);III(ap.);IV(ap.)
Pertusaria dactylina (Ach.) Nyl. I(st.);III(st.)
P. oculata (Dickson) Th. Fr. I(ap.);III(st.);IV(st.)
Phaeocalicium compressulum (Nyl. ex Szat.) A. Schmidt III(ap.);IV(ap.)
Phaeophyscia endococcina (Körber) Moberg IV(ap.)
P. sciastra (Ach.) Moberg I(st.);II(st.);III(st.)
Physcia adscendens (Fr.) Oliv. I(st.)
P. caesia (Hoffm.) Fürnrohr I(st.);II((st.);IV(st.)
P. dubia (Hoffm.) Lettau I(st.);II(st.);III(st.);IV(st.)
P. magnussonii Frey I(ap.)
P. phaea (Tuck.) Thomson III(ap.)
P. tenella (Scop.) DC. in Lam & DC. var. marina (Nyl.) Lynge I(st.)
Physconia detersa (Nyl.) Poelt I(st.);III(st.)
P. muscigena (Ach.) Poelt I(st.);III(st.)
P. perisidiosa (Erichsen) Moberg III(st.)
Placopsis gelida (L.) Linds. I(st.)
Placynthiella uliginosa (Schrader) Coppins & P. James IV(ap.)
Placynthium asperellum (Ach.) Trevis. I(st.);III(st.)
Platismatia glauca (L.) W. Culb. & C. Culb. I(st.)
Porpidia flavocaerulescens (Hornem.) Hertel & Schwab I(ap.);II(ap.);IV(ap.)
P. pseudomelinodes Schwab I(st.);III(st.);IV(st.)
P. speirea (Ach.) Krempelh. III(ap.);IV(ap.)
Protoblastenia rupestris (Scop.) Steiner IV(ap.)
Protoparmelia badia (Hoffm.) Hafellner I(ap.);II(ap.);IV(ap.)
Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw. II(ap.);III(st.);IV(st.)
P. pubescens (L.) Choisy I(st.);II(ap.);III(st.);IV(st.)
Psora rubiformis (Ach.) Hook. III(ap.)
Psoroma hypnorum (Vahl) S. F. Gray I(ap.);II(ap.);III(ap.)
Rhizocarpon disporum (Naeg. ex Hepp) Müll. Arg. I(ap.)
R. geminatum Körber I(ap.);II(ap.);IV(ap.)
R. geographicum (L.) DC. I(ap.);II(ap.);III(ap.);IV(ap.)
R. grande (Flörke ex Flot.) Arn. I(ap.);II(ap.);III(ap.);IV(ap.)
R. inarense (Vainio) Vainio I(ap.);III(ap.)
R. jemtlandicum (Malme) Malme I(ap.);III(ap.);IV(ap.)
R. polycarpum (Hepp) Th. Fr. I(ap.)
R. praebadium (Nyl.) Zahlbr. III(ap.)
R. rittokense (Hellb.) Th. Fr. I(ap.);III(ap.);IV(ap.)
R. superficiale (Schaerer) Vainio I(ap.)
Rhizoplaca chrysoleuca (Sm.) Zopf III(ap.)
R. melanophthalma (DC. in Lam. & DC.) Leuckert & Poelt III(ap.)
Rinodina cacuminum (Th. Fr.) Malme I(ap.);II(ap.);III(ap.);IV(ap.)
R. servediicola Degel. III(ap.)
R. turfacea (Wahlenb.) Körber I(ap.);II(ap.)
Solorina bispora Nyl. I(ap.)

S. crocea (L.) Ach. I(ap.; infested by Rhagadostoma lichenicola (de Not.) Keissler); III(ap.);IV(ap.)
Sphaerophorus fragilis (L.) Pers. I(st.);II(st.);III(st.);IV(st.)
S. globosus (Huds.) Vainio I(st.);II(st.);III(st.);IV(st.)
Sporastatia polyspora (Nyl.) Grumm. I(ap.);II(ap.)
S. testudinea (Ach.) Massal. III(ap.)
Stereocaulon alpinum Laur. I(ap.; infested by Scutula stereocaulorum (Anzi) Körber); II(st.);III(st.)
S. arenarium (Sav.) Lamb I(st.);III(st.);IV(st.)
S. botryosum Ach. I(st.);III(st.);IV(st.)
S. capitellatum Magnusson I(st.)
S. paschale (L.) Hoffm. I(ap.);III(st.);IV(st.)
S. rivulorum Magnusson I(st.)
S. vesuvianum Pers. I(st.);II(st.)
Tephromela aglaea (Sommerf.) Hertel & Rambold III(ap.)
T. armeniaca (DC.) Hertel & Rambold I(ap.)
Thamnolia vermicularis (Sw.) Schaerer I;II
Toninia sedifolia (Scop.) Timdal III(st.)
Trapeliopsis granulosa (Hoffm.) Lumbsch I(st.);III(st.);IV(st.)
Tremolecia atrata (Ach.) Hertel I(ap.);II(ap.);III(ap.);IV(ap.)
Umbilicaria arctica (Ach.) Nyl. I(ap.);II(ap.);III(ap.);IV(ap.)
U. cinereorufescens (Schaerer) Frey III(st.)
U. cylindrica (L.) Del. ex Duby I(ap.);II(ap.);III(st.)
U. decussata (Vill.) Zahlbr. III(st.)
U. deusta (L.) Baumg. II(st.);IV(st.)
U. havaasii Llano III(ap.);IV(ap.)
U. hirsuta (Sw. ex Westr.) Hoffm. III(st.)
U. hyperborea (Ach.) Hoffm. I(ap.);II(ap.);III(ap.);IV(ap.)
U. proboscidea (L.) Schrader I(ap.);II(ap.);III(ap.);IV(ap.)
U. rigida (du Rietz) Frey I(ap.);IV(st.)
U. torrefacta (Lightf.) Schrader I(ap.);II(ap.);III(ap.);IV(ap.)
U. vellea (L.) Ach. I(ap.);III(st.)
U. virginis Schaerer I(ap.);II(ap.);III(ap.);IV(ap.)
Varicellaria rhodocarpa (Körber) Th. Fr. III(ap.);IV(ap.)
Verrucaria ceuthocarpa Wahlenb. in Ach. I(pe.)
V. erichsenii Zsch. I(pe.)
Vestergrenopsis isidiata (Degel.) E. Dahl I(st.);IV(st.)
Xanthoria candelaria (L.) Th. Fr. I(ap.);II(ap.);III(ap.);IV(ap.)
X. elegans (Link) Th. Fr. I(ap.);II(ap.);III(ap.)
X. sorediata (Vainio) Poelt III(st.)

TYPES OF VEGETATION RICH IN LICHENS

The ecological and floristical works dealing with the Greenland vegetation are often very poor in information on lichens. This plant group is considered "difficult" by many botanists and is therefore often neglected and rather superficially treated. In the following, a survey of the lichen vegetation and flora of the Godthåb fjord area is given.

A. CORTICOLOUS FLORA

The oceanic and relatively cold climate at Nuuk largely prevents development of extensive thickets of shrubs apart from some protected, southfacing slopes in the mountain area. The fact that no epiphytes were found on the Salix-shrubs in the vicinity of Nuuk, is probably not due to air pollution, but can primarily be explained by the unfavourable climate.

Corticolous lichens occur, however, abundantly at some sites rich in shrubs of Alnus crispa in the two subcontinental areas at Qasigiánguit and Kapisigdlit. The Alnus-shrubs are up to more than two metre high and are either found along glacial streams or as proper thickets together with Salix glauca. Totally, shrubs occupy comparatively small areas.

The following species of lichens were found growing on bark of Alnus at both Qasigiánguit and Kapisigdlit: Cetraria pinastri, C. sepincola, Lecanora symmicta, Lecidea fuscescens, L. vernalis, Parmelia septentrionalis, Parmeliopsis ambigua (Lich. Groenl. Exc. 396), Phaeocalicium compressulum and Varicellaria rhodocarpa. Parmelia saxatilis occurs epiphytically (on Alnus) at Kapisigdlit, only. Parmeliopsis hyperopta was found growing on Alnus crispa and Betula nana at Qasigiánguit. Occasionally Cladonia fimbriata occurs on rotting trunks of Alnus. Further details about corticolous lichens in southwestern Greenland may be found in E. S. Hansen (1978a) and Alstrup (1982).

On Qornoq island and at Kapisigdlit lignum in, for example, constructions for drying of fish are important substrates for native as well as introduced species of lichens (Alstrup 1977). Thus some common epilithic lichens such as Candelariella arctica, Physcia caesia and Xanthoria elegans grow on lignum at Qornoq. No doubt these species are of local origin just as the two species, Physcia dubia and Xanthoria candelaria, which occur abundantly upon the wood constructions at Kapisigdlit.

B. DWARF SHRUB HEATHS AND OTHER TYPES OF EPIGEIC VEGETATION

Empetrum hermaphroditum heaths occur commonly in exposed places around Nuuk. A particular near-shore type of Empetrum heath is very poor in lichens, Nephroma arcticum being the most important species. Another more open and windblown type, which is usually found at higher elevations, is rich in lichens such as Alectoria nigricans, A. ochroleuca, Bryoria chalybeiformis, Cetraria islandica, C. nivalis, Cladina mitis, Coelocaulon muricatum, and Sphaerophorus globosus. These heath types, both of which are almost constantly snowcovered during winter, have a wide distribution in Greenland apart from the northernmost areas (Böcher 1954; E. S. Hansen 1978a,b, 1990a; Daniëls 1982).

Moist, open soil on north-facing slopes with Empetrum, is gradually colonized by Cladonia bellidiflora, C. macrophylla, C. pleurota and C. sulphurina. Salix herbacea, Cladonia ecmocyna and Pertusaria oculata often occur in association with Empetrum in places with a prolonged snowcover (Lille Malene, Store Malene, the cliffs between Nuuk and Nuussuaq). Other snowbeds are totally dominated by Solorina crocea. Moist depressions in the heaths are frequently occupied by a mosaic of Cetraria andrejevii and C. delisei, but as the last-mentioned species is very rare in East Greenland (E. S. Hansen 1986), this applies to the West Greenland heaths, only.

More complex types of dwarf shrub heaths generally replace the "pure" Empetrum heaths some distance away from the sea and the outer coast. In more dry places to the east of Nuuk Empetrum, Vaccinium uliginosum and Betula nana form a characteristic heath vegetation very rich in lichens. Most abundant are Cetraria nivalis, Cladina mitis, C. rangiferina, Stereocaulon alpinum, and more sparsely occurring are Cetraria islandica, Cladonia amaurocraea, C. pyxidata and Sphaerophorus globosus. There is no sharp limit between this type of dwarf shrub heath and the fell-field vegetation found at somewhat higher altitudes on the Greenland mountains (E. S. Hansen 1978a,b). Here the influence of strong winds means that the dwarf shrubs and other vascular plants, for example Juncus trifidus, Luzula confusa and L. spicata, either occur very scattered or are totally absent. Stereocaulon alpinum is often of minor importance, too. A small population of Cladina stellaris was found growing in an open Empetrum-Vaccinium-Loiseleuria procumbens heath at an altitude of c. 200 m a.s.l. on Store Malene. Cladina stellaris is rare in the vicinity of Nuuk, but becomes more common towards to inner parts of the fjords (Dahl 1950). An interesting variant of the Empetrum-Vaccinium-Betula nana community occurs near the northeastern border of Nuuk. In addition to dwarf shrubs, the flora consists of Carex rariflora, Cladina mitis, Cladonia uncialis and Scirpus caespitosus. It is developed at locations where water percolates over gneissic lowland rocks.

Dryas integrifolia avoids the acid soil in the gneissic area around Nuuk, but occurs in places where the soil is enriched with minerals derived from amphibolites and basic dykes. Thus, Dryas was found growing together with Carex nardina and Solorina bispora on exposed, gravelly soil at an altitude of c. 350 m a.s.l. on Lille Malene. According to Böcher (1954) the combination of Dryas and Carex nardina is not only found on plateaux and mountain tops, but also on broad, windexposed river plains in the continental part of South West Greenland.

A very luxuriant dwarf shrub-bog vegetation occurs in the lowland at Qasigiánguit a few metre from the Ameralik fjord. At this site Ledum decumbens, L. groenlandicum (dominant), Betula nana, Vaccinium uliginosum and Empetrum hermaphroditum are present together with the mosses Aulacomnium turgidum and Hylocomiun splendens. The lichens encountered were Cladina rangiferina, C. stellaris, Nephroma arcticum, Peltigera leucophlebia, P. scabrosa and Stereocaulon paschale, all with a relatively quick thallus growth. Additional Cladonia species at this site were Cladonia carneola, C. cenotea, C. cornuta, C. crispata, C. cyanipes, C. sulphurina and C. uncialis. Patches of lichen heaths dominated by Cladina stellaris are found on sloping ground somewhat above the boggy area. Salix glauca and Equisetum silvaticum also form more or less dense patches along the border of this area.

Well-developed Ledum decumbens-Betula nana heaths occur commonly at Kapisigdlit, especially on north-facing slopes with a constant snow-cover during the winter and permafrost c. 20-30 cm under the vegetation (Böcher 1954). Lichen species found in this type of heath include Alectoria ochroleuca, Cetraria nivalis, Cladina mitis, C. stellaris, Nephroma arcticum, Peltigera leucophlebia, P. scabrosa, Sphaerophorus globosus, Stereocaulon alpinum, and more rarely Dactylina arctica. A more species-poor, but otherwise similar heath vegetation is found on the southeastern part of Qornoq. Above 100 m on Pingo a fragmentary Cassiope tetragona-Vaccinium vitis idaea heath appears on north-facing ground. The soil here is acid and rich in humus. Dactylina arctica and Nephroma expallidum are the most important lichens in this community. At an elevation of 200 metre on the southwest-facing side of Pingo an interesting steppe vegetation consisting of Artemisia borealis, Kobresia myosuroides and Cetraria nivalis is developed on dry soil derived from an occurrence of amphibolite. A thin layer of soil in some rock fissures are colonized by Catapyrenium lachneum, Psora rubiformis and Toninia sedifolia. The present author has studied similar steppe patches near the head of Søndre Strømfjord (67°N) and Christianshåb (69°N) in the summer of 1992.

C. THE LICHEN FLORA ON BIRD-PERCH ROCKS

The Godthåb fjord region is characterized by a rich bird fauna including several gull species, ravens, white-tailed eagles, snow buntings and Lapland buntings, all of which influence the lichen vegetation by the high concentration of ammonia and nitric acid in the guano (Salomonsen 1979). The following intends to provide a survey of the most important types of lichen vegetation on bird-perching rocks in the Godthåb fjord area and to describe the relationship between rock type, birds and lichen species.

Vertical or strongly sloping rock surfaces that are exposed directly to the sea (and accordingly greatly influenced by seawater spray) and manured by gulls dropping guano on the top of the rock often support an open vegetation with Acarospora molybdina, Caloplaca alcarum and Lecanora contractula. The last-mentioned species infests the Lecanora and frequently destroys it almost totally. Caloplaca alcarum is known from Greenland, Svalbard, Novaya Zemlya and the Siberian arctic (E. S. Hansen, Poelt & Søchting 1987; Søchting, Zhurbenko & E. S. Hansen 1992). In more protected places, but still close to the sea, Caloplaca alcarum and Lecanora contractula are accompanied by species such as Buellia coniops, Caloplaca scopularis, Candelariella arctica and Physcia tenella var. marina. The community reaches its optimum development near the outer coast, but can still be found (in somewhat reduced form) on

Qornoq and at Kapisigdlit.

Strongly eutrophicated seashore rocks rich in nitrophilous lichen species occur at many sites near Nuuk, for example, in its southern part and in Malenebugt. Candelariella arctica and Lecanora straminea are often dominant on such rocks. Other common species are Parmelia disjuncta, P. infumata, P. saxatilis, P. sulcata, Physcia caesia, Physcia dubia, Umbilicaria arctica, Xanthoria candelaria, X. elegans and the following crustose lichens: Aspicilia caesiocinerea, Candelariella vitellina, Lecanora intricata, L. polytropa, Rhizocarpon geminatum, R. grande, Rinodina cacuminum. This flora was found on Nuuk gneisses of all aspects and slopes, but it is generally best developed on horizontal and slightly sloping surfaces. Part of these rocks are not only influenced by bird excreta, but probably also by fish and seal offal etc. The same applies to a horizontal rock face dominated by Lecanora straminea near the houses on Qornoq and a vertical, northwest-facing rock dominated by Xanthoria elegans at Kapisigdlit. A rather impoverished ornithocoprophilous vegetation occurs on a steep, rocky hill with a statue of the famous missionary Hans Egede just above Nuuk's "Old Church". This vegetation shows signs of damage caused by tourists. One species, viz. Caloplaca fraudans, has a distinct preference for such worn and weathered rocks at Nuuk as well as other parts of Greenland (E. S. Hansen, Poelt & Søchting 1987).

A vertical, south-facing rock composed by Nuuk gneiss and manured by ravens near Malenebugt appears to be comparatively rich in Physcias. One species, Physcia adscendens, is very rare in Greenland, known so far only from Qivaqe and Nuuk (Moberg & E. S. Hansen 1986). Another species of Physcia, P. magnussonii, grows on basaltic and siliceous rocks in South West Greenland. Both of the dominants on the raven rock, Parmelia saxatilis and Physcia caesia, are common all over Greenland. A very special case was observed on a steep and several metre high rock c. 12 km west of Nuuk. The whole surface of the rock was coloured yellow by thalli of Lecanora straminea. The rock is exposed directly to the sea and is probably manured by different seabirds.

Loose rock substrates such as stones and boulders, generally hold a somewhat reduced ornithocoprophilous lichen flora compared to that occurring on the abovementioned bedrock gneisses. The vegetation on the top surface of a ca. 1 m high gneissic boulder at Qasigiánguit was studied: Candelariella arctica, which is considered extremely ornithocoprophilous by Lynge (1928; see also Grønlie (1948)), is dominant. Notable are also Acarospora peliscypha, Parmelia fraudans and P. sulcata. The fact that Candelariella arctica is not restricted to localities near the outer coast can also be illustrated by an example from Kapisigdlit. Here the species grows on the south-facing surface of a gneissic boulder in association with Acarospora molybdina, Dimelaena oreina, Lecanora polytropa, L. straminea, Physcia caesia, P. dubia, Rhizoplaca melanophthalma, Umbilicaria arctica and Xanthoria elegans. The top surface of this boulder is covered by Aspicilia caesiocinerea, Bryoria chalybeiformis, Parmelia saxatilis, P. sulcata, Rhizoplaca melanophthalma, Umbilicaria arctica (dominant) and Xanthoria candelaria. Another small boulder studied at Kapisigdlit (alt. 35 m) holds the following species at its top face: Aspicilia caesiocinerea, Candelariella vitellina, Lecanora intricata, L. polytropa, Parmelia saxatilis, P. sulcata, Rhizocarpon geographicum, Umbilicaria arctica and Xanthoria candelaria (dominant). Two species, Lecidea atrobrunnea and Protoparmelia badia, which in South East Greenland are common on such scattered erratic boulders that are often manured by snow buntings (E. S. Hansen 1978b), appear to be comparatively rare in the Godthåb fjord area. On the other hand, species such as Caloplaca scopularis and Candelariella arctica are not at all known from the east coast of Greenland. Aspicilia caesiocinerea was recently reported as an addition to the lichen flora of West Greenland (E. S. Hansen 1986; see also Daniëls 1975), but it cannot be rare, as the present author has collected it at many localities during the last few years.

A very special epilithic inland flora occurs on some gneissic boulders situated in the valley extending southwards from Kapisigdlit. At least a part of these boulders are influenced by raven excreta, some of them probably also by reindeer dung, as large herds of these animals live in this area, (reindeer skeletons are often very rich in lichens such as Candelariella aurella and Lecidella euphorea, Physcia caesia and other Physcias, Xanthoria candelaria and X. elegans). Hypogymnia oroarctica and Xanthoria elegans are dominants on the top surface of some of the boulders, while species such as Parmelia centrifuga, Pseudephebe minuscula and Umbilicaria hyperborea are comparatively scarce. These species are facultatively ornithocoprophilous in contrast to, for example, Aspicilia caesiocinerea, Parmelia infumata, P. sulcata, and Rhizoplaca melanophthalma, which are obligate ornithocoprophile. Of particular interest are Lasallia pensylvanica, Umbilicaria cinereorufescens, Hypogymnia austerodes and Rhizoplaca chrysoleuca, all of which are favoured by the continental conditions prevailing in the inland area (E. S. Hansen 1971). South-facing, vertical surfaces of these boulders sometimes hold Nephroma parile and Peltigera collina.

Part of the Amiitsoq gneisses investigated on Lille Malene, at Qasigiánguit and at Kapisigdlit are distinctly influenced by guano and support a flora with a marked preference for nutrient-enriched substrates. Numerous thalli of Umbilicaria rigida were found growing on a horizontal bird-perch rock at an altitude of 280 m on Lille Malene. However, 16 lichen species were recorded from a north-facing rock at Qasigiánguit. Most of them, for example, Diploschistes scruposus, Parmelia centrifuga, P. incurva, Umbilicaria havaasii and U. virginis are facultatively ornithocoprophilous, while species such as Lecanora argopholis, Protoparmelia badia and Umbilicaria arctica have a distinct preference for bird-perch rocks. At Kapisigdlit some hard rocks composed of Amiitsoq gneiss support a vegetation dominated by Dimelaena oreina and Xanthoria elegans. Associates include Lecanora intricata, Parmelia disjuncta, Phaeophyscia sciastra and Physcia caesia. The two species, Pseudephebe minuscula and Umbilicaria lyngei, are able to tolerate the fairly high concentration of nitrogen compounds on the rock faces investigated. This association has a wide distribution in Greenland and occurs so far northwards as Qaanaaq (77°29'N) (E. S. Hansen 1989; E. S. Hansen & Dawes 1990). The basal part of such gneissic rocks on Pingo at Kapisigdlit sometimes holds Xanthoria sorediata, particularly in somewhat moist and shady places that are exposed to the north. These rocks are manured by ravens as well as by reindeer staying here. The south-facing amphibolitic rocks occurring at an altitude of c. 200 m on Pingo and supporting species such as Lecanora intricata and L. reagens (in rock fissures), Placynthium asperellum, Rhizocarpon geminatum, Rhizoplaca chrysoleuca (infested by Caloplaca epithallina) and Xanthoria elegans, are probably influenced both by raven guano and by the minerals of the rock (E. S. Hansen 1990b).

D. THE LICHEN FLORA ON ROCKS WITHOUT VISIBLE INFLUENCE OF GUANO

The epilithic lichen vegetation on rocks, where birds do not perch, is characterized by the lack of obligate ornithocoprophilous species. The effect of moisture, wind, nutritious dust etc. and the great diversity of rock substratum in the Godthåbfjord area result, however, in a number of different flora types, of which the most important will be outlined in the following.

The littoral zone along the coast around Nuuk often supports a flora of seashore lichens, which are poor in species, but nevertheless very typical of more sheltered coast localities in West Greenland. Verrucaria ceuthocarpa and V. erichsenii, both growing on rocks, and Arthopyrenia sublitoralis, which colonizes exoskeletons of acorn barnacle, are the most significant lichens in this zone (Lynge 1937; E. S. Hansen 1983, 1984). The most interesting species, Verrucaria degelii, which previously was reported from West Greenland by E. S. Hansen (1986), has so far not been collected in the Godthåb fjord area.

In places where steep rock surfaces continue deeply into the seawater, no lichens occur in the littoral zone. The zone just above, however, is not rarely dominated by Tremolechia atrata and Umbilicaria torrefacta. This vegetation gradually becomes more rich in species with increasing distance from the sea. Exposed, near-shore rocks composed by Nuuk gneiss are dominated by species such as Ochrolechia tartarea, Orphniospora moriopsis, Pseudephebe minuscula and P. pubescens. Vegetation of this type was studied on a north-facing rock at an altitude of 50 m near Nuuk. Allantoparmelia alpicola, Cetraria hepatizon, Parmelia omphalodes, Rhizocarpon geographicum and the three Umbilicaria species, U. hyperborea, U. proboscidea and U. torrefacta are additional widespread lichens at this site. The lichen communities found on both types of gneiss, on dolerite, on quartz and on amphibolite in the Nuuk area (all aspects and slopes), includes Lecanora polytropa, P. centrifuga, P. saxatilis, Rhizocarpon inarense, Sphaerophorus fragilis, Umbilicaria cylindrica and very rarely, Platismatia glauca. The last-mentioned species was observed on the top of a rock just south of Nuussuaq. In Greenland it has previously been found growing on the ground in fell-fields, on bark of, for example, Salix glauca and Betula nana, but most frequently on rocks and boulders (Dahl 1950; E. S. Hansen 1971; Alstrup 1982; Thomson 1984). Platismatia glauca has so far not been collected in East Greenland. The species is distinctly in need of protection because of its relatively few localities in Greenland.

The fact that strongly weathered gneissic rocks can be fairly rich in lichens, is illustrated by the following example: The rough surface of a rock situated near the settlement of Kapisigdlit allows "epigaeic" macrolichens such as Alectoria sarmentosa ssp. vexillifera and Bryoria chalybeiformis to attach to it. The rock is very unusual holding two species of Hypogymnia, viz. H. austerodes and H. physodes, together with Brodoa oroarctica. More widespread species on the rock include Orphniospora moriopsis, Parmelia saxatilis, Sphaerophorus fragilis, Umbilicaria hyperborea and U. proboscidea. These are accompanied by five species of Rhizocarpon, viz. R. inarense, R. jemtlandicum, R. praebadium, R. rittokense and R. superficiale. Umbilicaria havaasii does not occur on this rock, but is a common and sometimes dominant lichen on other rocks composed by Nuuk gneiss at Kapisigdlit. In many respects the Amiitsoq gneiss is similar to the Nuuk gneiss, floristically. The lichen vegetation on a damp and very hard rock of the first-mentioned type located near a stream at Qasigiánguit differs, however, from the flora on the Nuuk gneises by the occurrence of, for example, Amygdalaria panaeola, Bellemerea cinereorufescens, Caloplaca nivalis, Lecanora chloroleprosa and Vestergrenopsis isidiata. Ephebe lanata and Umbilicaria deusta also belong to this community on rock surfaces influenced by seeping water. A sheltered, damp rock surface occurring at an altitude of 300 m on Lille Malene supports Lecidea marginata, Placopsis gelida and Umbilicaria virginis indicating a weak influence of basic minerals. On the other hand, rock faces which are exposed to strong winds often hold species such as Haematomma ventosum and Tephromela armeniaca (the rocky hills between Nuuk and Nuussuaq, Lille Malene and Store Malene).

Presence of iron-containing minerals generally influences the lichen vegetation markedly as seen on an almost vertical, west-facing rock patchly coated with limonite and situated near a stream at Qasigiánguit. The ferrugineous lichens, Acarospora sinopica, Lecidea atrofulva and Porpidia flavocaerulescens, occur in small quantity, and Miriquidica nigroleprosa and Tremolecia atrata are dominants. This association appears to be widely distributed on rocks rich in iron-containing minerals in Greenland and Scandinavia (Creveld 1981; E. S. Hansen 1986). Ferrugineous lichens were also found growing on Nuuk gneiss, for example, at an altitude of 350 m on Store Malene (Porpidia flavocerulescens) and on Qornoq, where Lecidea atrofulva covers a vertical, south-exposed rock totally. In other semi-moist parts of Qornoq such rocks are covered by Tremolecia atrata.

Rocks composed of dolerite are more resistant than gneissic rocks and therefore often rise above them as distinct dark zones in the paler gneiss. A weak dominance of Orphniospora moriopsis, Porpidia flavocaerulescens and Rhizocarpon jemtlandicum was found on a dolerite rock just northwest of Nuussuaq. A further 23 species were recorded on this west-exposed rock, all of them well-known from the gneissic rocks around Nuuk as well as many other parts of West Greenland (Hansen 1989). The dolerite rocks differ, however, from the the gneissic, which they intersect, by the relative abundance of ferrugineous lichens such as Porpidia flavocaerulescens and the two species, Acarospora sinopica, Lecidea atrofulva. Another dolerite rock to the west of Nuussuaq supports a rich flora of the following crustose lichens: Caloplaca nivalis, Lecanora intricata, L. polytropa, Lecidea atrofulva, L. lactea, L. lapicida, Miriquidica nigroleprosa, Protoparmelia badia, Rhizocarpon geminatum, R. polycarpum, R. superficiale, Sporastatia polyspora and Tremolecia atrata. This community was also found growing on dolerite on Qornoq and near a small stream on Lille Malene (alt. 200 m).

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A new species of Botryotrichum parasitic on nematode eggs.

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A new species of Botryotrichum is described from nematode eggs collected from a Brazilian soil. The species differs from previously described species based on the presence of setae and the relatively small size of the macroconidia.

Recent investigations (Santos et al., 1991) of soil flora which are pathogenic or parasitic on nematodes yielded an interesting hyphomycete which readily colonized living nematodes. The fungus produced both macroconidia, microconidia and setae and is classifiable in the genus Botryotrichum Sacc & Marchal (Downing, 1953; Ellis, 1971). Since the fungus differed from other previously described species of this genus, it is described as new. Color terminology is from Kornerup & Wanscher (1978).

Botryotrichum nematophagus M.A. Santos, Muchovej & S. Ferraz
Fig. 1.

Colonia velutina ad floccosa, rufa ad rufobrunnea. Hyphae hyalina quando juvenile, cum aetis subfusca, septata, 1.5-3 µm crasse. Cellae conidiifera duotypi. Holoblastica, micronematosa, microextensionis. Phialidica minuta, hyalina, cylindrica. Conidii duotypi. Macroconidii ovoidum vel globosum, laevum, aseptatum, crassitunicatum, hyalinum quando juvenile, cum aetis fulvum, 9.5-12.5 µm, tunicatum 1.3-2.5 µm. Microconidii minutum, hyalinum, globosum, tenuietunicatum, aseptatum, 1.2-2 µm. Setae brunneum, ad 200 µm longitudinis.
Holotypus: ex helminthus, UFV. leg Santos

Colonies velvety to cottony, dull red (8B3) to pale red (7A3) in the centers, brownish orange (7C3) on the edges, reverse brown (7E5 - 7F5). Hyphae hyaline when young, darkening with age, septate, 1.5-3 µm wide. Conidiogenic cells of 2 types: holoblastic, integrated, macronematous, with small (<3 µm) extensions; or phialidic, minute, aseptate, cylindrical, hyaline. Conidia of 2 types. Macroconidia ovoid to globose, smooth, thick walled, aseptate, initially hyaline, becoming light golden brown with age, 9.5-12.5 µm, wall 1.3-2.5 µm. Microconidia phialospores, minute, hyaline, globose, thin walled, aseptate, 1.2-2 µm. Setae brown, septate, wide at the base, narrowing gradually to the apex which is subhyaline, up to 200 µm in length, 5-7 µm at the base.

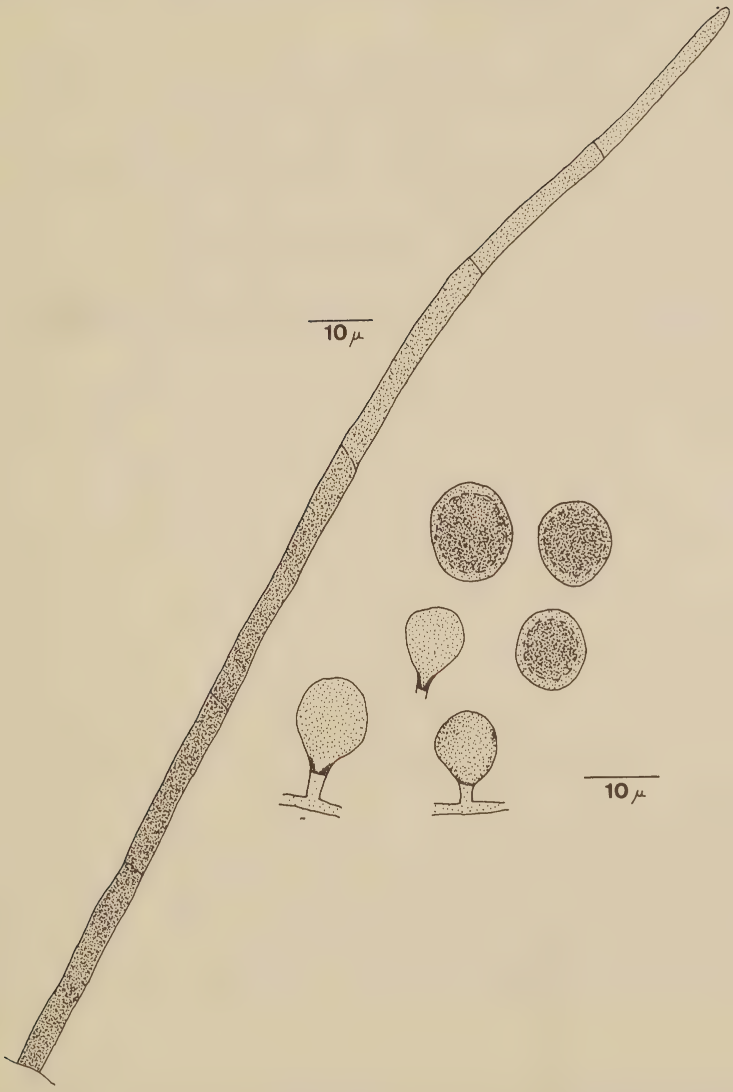
This fungus is of interest in its parasitic habit on nematode eggs. The other species which have been included in the genus *Botryotrichum* differ from our species in the following manner. *Botryotrichum piluliferum* produces setae, however the macroconidia are larger (10-21 µm) and hyaline, with a thicker wall (up to 3.5 µm), and surrounded by a hyaline membrane which commonly separates from the main wall and ruptures in mounts (Downing, 1953). These characteristics were not seen in our fungus. Neither *B. keratinophilum* Kushwaha & Agrawal nor *B. atrogriseum* vBeyma produce setae. *B. atrogriseum* has dematiaceous hyphae and black microconidia while the hyphae of *B. keratinophilum* is hyaline as are the microconidia. Downing (1953) excluded *B. atrogriseum* from *Botryotrichum* because of the lack of setae. Accepting production of setae as an essential characteristic of the genus then casts doubt on the placement of *B. keratinophilum* in this genus. The species are easily separated.

1. Setae present 2
   Setae absent 3
2. Mature macroconidia hyaline, with a hyaline membrane which commonly separates in mounts . . . . *B. piluliferum*
   Mature macroconidia light golden brown, without a separable membrane . . . . *B. nematophagus*
3. Mycelium hyaline . . . . *B. keratinophilum*
   Mycelium dematiaceous . . . . *B. atrogriseum*

Peziotrichum is a similar genus with respect to conidiogenic cells and conidia, however, the setae are placed around the perimeter of the colony (Petch, 1912) which gives it a sporodochium-like appearance. Also, the type species, *Peziotrichum lachnella* Sacc. has an *Ophionectria* perfect state (Petch, 1912) while *B. piluliferum* has a *Chaetomium* perfect state (Ellis, 1971). To date no perfect state has been found for *B. nematophagus*.

Based on the characteristics of setae, macroconidia and microconidia, *B. nematophagus* fits well in the genus *Botryotrichum*, however studies on *B. keratinophilum* and *B. atrogriseum* are needed to assure the correct placement of these 2 species.

Figure 1. Camara lucida drawing of setae and macroconidia of *Botryotrichum nematophagus* from culture.


10 μ
10 μ

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TAXONOMIC NOTES ON SOME SPECIES OF THE CERCOSPORA COMPLEX (III)

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Summary: The new species *Cercospora erigeronicola* spec. nov. is described and the following new combinations and new names are introduced: *Cercospora hedericola* (Heald & Wolf) comb. nov., *Cercospora junci-marginati* nom. nov., *C. scorzonerae* (v. Höhn.) comb. nov., *Mycovellosiella acalyphae* (Tharp) comb. nov., *M. bauhiniae* (Ell. & Ev.) comb. nov., *M. delicatissima* (Kalchb. & Cooke) comb. nov., *M. dulcamarae* (Peck) comb. nov., *M. isotomae* (Cif.) comb. nov., *M. pilophila* (Jacz. ex Vasil'evskij & Karakulin) comb. nov., *M. pirina* (Ell. & Ev.) comb. nov., *M. pyri* (Farlow) comb. nov., *M. subrufa* (Ell. & Holw.) comb. nov., *Passalora astragali* (Ell. & Ev.) U. Braun var. *epiphylla* (Ell.) comb. nov., *P. chionea* (Ell. & Ev.) comb. nov., *P. oleacearum* (Chidd.) comb. nov., *Phaeoisariopsis elata* (Sacc.) comb. nov., *Phaeoramularia momordicae* (Heald & Wolf) comb. nov., *P. viburni* (Ell. & Ev.) comb. nov., *Pseudocercospora asphodelina* (Sacc.) comb. nov., *P. valerianae* (Solheim) comb. nov., *P. viticicola* nom. nov., *Septoria crepidicola* nom. nov., *Sporidesmium olivascens* (Thüm.) comb. nov. and *Stenella sardoa* (Sacc.) comb. nov. *Cylindrosporium kaki* Syd. is reduced to synonymy with *Pseudocercospora diospyri-morrisianae* (Sawada) ex Goh & Hsieh. The genus *Mycocentrospora* is reassessed. All aquatic and *Pseudocercospora*-like *Mycocentrospora* species are excluded. The new combinations *Pseudocercospora cantuariensis* (Salm. & Worm.) comb. nov., *P. camelliae* (Deighton) comb. nov., *P. cladosporioides* (Sacc.) comb. nov. and *Pseudocercosporella trichophila* (Davis) comb. nov. are introduced.

Ramularia, Cercosporella and allied genera are closely connected with the *Cercospora* complex. Misinterpretations and misapplications of particular genera are not uncommon. Most of the following taxa have been examined during monographic studies on the *Ramularia/Cercosporella* complex.

(1) *Cercospora* Fres.

Cercospora erigeronicola U. Braun & C. T. Rogerson spec. nov.

Maculae amphigenae, angulares, irregulares, flavidae, ochraceae vel brunneae, interdum leniter purpureo-brunneae. Caespituli hypophylli, punctiformes, griseo-brunnei. Mycelium immersum. Stromata bene evoluta, ca. 10-80 µm lata, substomatalia vel intraepidermalia, flavido-brunnea, olivacea vel brunnea. Conidiophora dense fasciculata, numerosa, filiformia, 10-50 x 2-3.5 µm, simplicia, recta vel flexuosa, leniter geniculata-sinuosa, subhyalina, viridula vel pallide olivacea, continua vel leniter septata. Cicatrices conidiales conspicuae, incrassatae, obscurae. Conidia solitaria, plus minusve cylindrica, 15-45 x 2-3.5 µm, 0-3 septata, laevia, hyalina vel subhyalina (pallide viridula), apice obtusa, basi truncata, leniter incrassata et obscura. Fig. 1.

Holotype: on *Erigeron divergens* Torr. & Gray, USA, Eden, Weber Co., Utah, 5-6-1966, Rogerson (NY).

Leaf spots amphigenous, angular, irregular, shape and size variable, yellowish, ochraceous to brownish, occasionally somewhat purplish brown. Caespituli hypophyllous, punctiform, greyish brown. Mycelium internal, forming well developed stromata, ca. 10-80 µm diam., substomatal to intraepidermal, yellowish brown, olivaceous to brown. Conidiophores in dense, rich fascicles, filiform, 10-50 x 2-3.5 µm, simple, straight to flexuous, slightly geniculate-sinuous, subhyaline, greenish to pale olivaceous, continuous to sparsely septate. Conidial scars conspicuous, thickened and darkened. Conidia solitary, more or less cylindric, 15-45 x 2-3.5 µm, 0-3-septate, smooth, hyaline or subhyaline (pale greenish), apex obtuse, base truncate, hila somewhat thickened and darkened.

The present species is very unusual, but owing to coloured conidiophores with thickened, darkened conidial scars and solitary conidia, it is referred to *Cercospora*.

Cercospora hedericola (Heald & Wolf) U. Braun comb. nov.

Bas.: *Ramularia hedericola* Heald & Wolf, Mycologia 3, p. 21 (1911).

Holotype: on *Hedera helix*, USA, San Marcos, Texas, 14-8-1909, Heald & Wolf (BPI).

Leaf spots amphigenous, shape irregular, large, 5-30 mm diam., ochraceous, brown, greyish brown, greyish white, with raised, dark marginal line. Caespituli amphigenous, mostly epiphyllous, punctiform, dark, blackish. Mycelium internal, forming substomatal stromata, brown. Conidiophores in dense, rich fascicles, ca. 10-80, straight, subcylindric to geniculate, simple, 15-100 x 3-5 µm, septate, yellowish brown to medium brown, paler towards the apex, smooth, conidial scars thickened and darkened. Conidia solitary, acicular (- sub-

cylindric), 10-150 x 1.5-3.5 µm, hyaline, obscurely multiseptate, smooth, hila somewhat thickened and darkened. Fig. 2.

This species is a typical *Cercospora*. *C. hederae* Katsuki & Togashi is quite distinct by non-fasciculate conidiophores.

Cercospora junci-marginati U. Braun nom. nov.

Bas.: *Ramularia junci* Peck, Ann. Rep. N.Y. State Mus. 44, p. 26 (1891).

Holotype: on *Juncus marginatus*, USA, Selkirk, N.Y., Peck (NYS).

Leaf spots amphigenous, brown, elongated, ca. 2-10 x 1-2 mm, margin indefinite. Caespituli amphigenous. Mycelium internal, forming substomatal stromata, ca. 10-35 µm diam., yellowish brown. Conidiophores in dense, rich fascicles, emerging from stromata, through stomata, ca. 5-30 x 2-5 µm, simple, straight, subcylindric to geniculate-sinuous, aseptate, subhyaline, olivaceous to medium brown, smooth, conidial scars thickened and darkened. Conidia formed singly, acicular (- narrowly obclavate), 25-65 x 1.5-3 µm, hyaline, smooth, 1-5-septate, apex pointed, base truncate, hila slightly thickened and darkened. Fig. 3.

C. junci-filiformis Mel'nik differs by long, nodulose conidiophores and very broad conidia. *C. juncicola* (Hori & Kasei) Chupp is characterized by small fascicles, longer conidiophores and wider conidia. *C. juncina Sacc.* (= *C. junci* Davis) is distinguished by large stromata with very dense fascicles of longer conidiophores and wider conidia.

Cercospora scorzonerae (v. Höhnel) U. Braun comb. nov.

Bas.: *Cercosporella scorzonerae* v. Höhnel, Ann. Myc. 3, p. 338 (1905).

Holotype: on *Scorzonera humilis*, Austria, Wiener Wald, 1905, v. Höhnel (FH).

Syn.: *Ramularia scorzonerae-humilis* Nannf., in Lundell & Nannf., Fungi Exs. Suec., fasc. XXXIX-XL, Sched., p. 34 (1950).

This species belongs to *Cercospora* subgen. *Hyalocercospora* U. Braun (1992). The conidiophores are fasciculate, 5-45 x 2.5-5 µm, colourless, but the structure of the conidial scars does not coincide with the *Cercosporella* type. The conidial scars are somewhat thickened and darkened and agree with those of *Cercospora* species. The conidia are 20-100 x 1.5-4.5 µm, subhyaline, acicular, narrowly obclavate, 1-10-septate, hyaline. Fig. 4.

(2) *Mycocentrospora* Deighton emend. nov.

Mycocentrospora (= *Centrospora* Neergaard, homonym!) is, in the present sense, very heterogeneous. In the original sense, it was a monotypic genus. *M. acerina* (Hartig) Deighton, the type species, is a unique, soil borne, low temperature plant pathogen, characterized by internal as well as external mycelium, fasciculate or solitary conidiophores, arising through stomata or from superficial, secondary hyphae. The superficial mycelium and the conidiophores are colourless. The conidiogenous cells are polyblastic, sympodial with conspicuous, more or less flat, rigid scars, very slightly, evenly thickened throughout, but not darkened. The conidia are colourless or sometimes pale olivaceous, obclavate-acicular, broad, multiseptate, usually gradually tapering into a long, narrow apical beak, sometimes with continuous or septate basal branches. In culture, the mycelium becomes olivaceous with the formation of chains or groups of brown, thick-walled, swollen, chlamydospore-like cells. The broader central cells of the conidia may also turn to yellowish or pale brown.

Petersen (1962, 1963), Iqbal (1971, 1974) and Sinclair & Morgan-Jones (1979) added some aquatic hyphomycetes to *Mycocentrospora*. I agree with Deighton (1971) that aquatic hyphomycetes are not correctly placed in *Mycocentrospora* (= *Centrospora* Neerg.). The structure of the conidiophores and conidial scars does not agree with *Mycocentrospora acerina*. The conidiophores in most species are very long, filiform, sometimes branched, without typical zigzag configuration, and the conidial scars are not thickened and less conspicuous. The mycelium in *M. aquatica* (Iqbal) Iqbal and *M. clavata* Iqbal is brown. *M. varians* Sinclair & Morgan-Jones is the most *Mycocentrospora*-like aquatic hyphomycete. The exact taxonomic status of these species is, however, unclear. Three morphological entities are involved in this complex of species, i.e. *Anguillospora* Ingold, *Pseudoanguillospora* Iqbal and "aquatic *Mycocentrospora* species". It is not quite clear if the "aquatic *Mycocentrospora* species" must be referred to a new genus. This problem should be solved by specialists in aquatic hyphomycetology. The entire complex around *Anguillospora/Pseudoanguillospora* should be reassessed.

Deighton (1971, 1983) added some phytoparasitic hyphomycetes with coloured secondary mycelium, conidiophores and conidia. These species, e.g. *Mycocentrospora camelliae* Deighton and *M. cladosporioides* (Sacc.) Deighton, are *Pseudocercospora*-like. The fairly broad, flat conidial scars are unthickened and all structures are coloured. The width of the conidial scars in the *Cercospora* complex is usually correlated with the width of the produced conidia. But this feature is not useful for the delimitation of genera. Therefore, I prefer to refer the species in question to *Pseudocercospora*.

Because of superficial, colourless mycelium with solitary conidiophores and unthickened conidial scars, Braun (1993a) placed *Cercosporella trichophila* Davis provisionally in *Mycocentrospora*. But *C. trichophila* is an anomalous *Pseudocercosporella* species, characterized by superficial, secondary mycelium with solitary conidiophores. In this respect, it resembles *Pseudocercosporella granati* (Rawla) Deighton (1976b), *P. gymnosporiae* Bagyanarayana, U. Braun & Jagadeeswar (1993) and *P. crataegi* (Ell. & Ev.) U. Braun (1993b). Exceptional species with superficial hyphae are also known in *Ramularia* (Braun 1990) and *Cercosporella* (Deighton 1973).

Reassessment of *Mycocentrospora*

Mycocentrospora Deighton, Taxon 21, p. 716 (1972)

Syn.: *Centrospora* Neergaard, Zbl. Bakt. Parasitenk., Abt. 2, 104, p. 410 (1942), homonym! *Ansatospora* Newhall, Phytopathology 34, p. 98 (1944), nom. inval.

Mycelium hyaline to very dilute brown, septate, branched. Primary mycelium internal, secondary mycelium external, superficial (with torulose groups of swollen, hyaline to coloured cells). Stroma none (occasionally a few substomatal swollen hyphae). Conidiophores emerging through stomata in small fascicles, sometimes penetrating the cuticle away from the stomata, secondary conidiophores solitary, arising from superficial hyphae, colourless to coloured, smooth, continuous to septate, flexuous, geniculate, usually with characteristic zigzag configuration, conidiogenous cells integrated, terminal, polyblastic, sympodial. Conidial scars conspicuous, fairly broad, flat or slightly convex, rigid, slightly thickened throughout. Conidia solitary, obclavate-acicular, rostrate, frequently curved, base broadly truncate, septate, smooth to verruculose, hyaline to faintly coloured, the broader cells sometimes with slightly thicker walls, coloured, yellowish to pale brown and with slight constrictions at the septa, sometimes appendiculate with a septate, lateral appendage from the basal cell, but often without appendages.

Type species: *Mycocentrospora acerina* (Hartig) Deighton

Included species:

Mycocentrospora acerina (Hartig) Deighton, Taxon 21, p. 716 (1972), a soil borne, low temperature plant pathogen with wide host range (Deighton 1971, Ellis 1971).

Mycocentrospora verrucosa Pollack & Ellett, Mycologia 66, p. 172 (1974), the cause of foliar shot-hole of *Euonymus kiantschovica* in North America.

Mycocentrospora veratri (Peck) U. Braun, Nova Hedwigia 53, p. 269 (1991), the cause of leaf spots on *Veratrum* in Europe and North America.

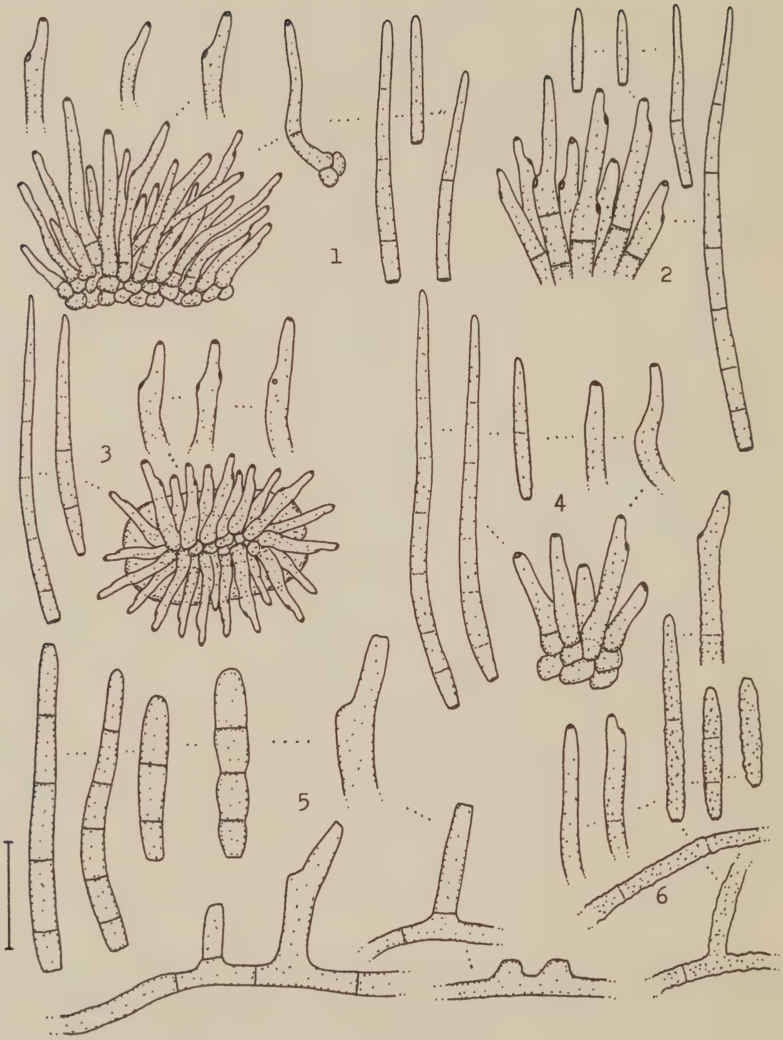

Fig. 1-6. Conidiophores, fascicles, conidia, superficial hyphae, 1 - *Cercospora erigeronicola*, 2 - *C. hedericola*, 3 - *C. junci-marginati*, 4 - *C. scorzonerae*, 5 - *Pseudocercospora cladosporioides*, 6 - *Stenella anomoconis*, from North America. Scale - 20 µm. U. Braun del.

Excluded species:

Centrospora bromi (Sprague) Newhall, Phytopathology 36, p. 895 (1946) = *Ramulispora bromi* (Sprague) Sprague, Diseases of Cereals and Grasses in North America, p. 418 (1950)

Centrospora macrospora (Osterw.) Neergaard, Gartnertidende 8, p. 97 (1943) = *Mycocentrospora acerina* (Deighton 1971)

Centrospora angulata Petersen, Mycologia 54(2), p. 129 (1962), *Mycocentrospora angulata* (Petersen) Iqbal, Biologia (Lahore) 20(1), p. 3 (1974) = *Anguillospora angulata* (Petersen) Wolfe, in Parker & Roane, Distributional History of the Biota of the Southern Appalachians, 4. Algae and Fungi, p. 245, Charlottesville "1976" (1977)

Centrospora filiformis (Greathead) Petersen, Mycologia 54(5), p. 584 ("1962", 1963), *Mycocentrospora filiformis* (Greathead) Iqbal, Biologia (Lahore) 20(1), p. 3 (1974) = aquatic hyphomycete (excluded!)

Centrospora aquatica Iqbal, Trans. Br. mycol. Soc. 56(3), p. 351 (1971), *Mycocentrospora aquatica* (Iqbal) Iqbal, Biologia (Lahore) 20(1), p. 3 (1974) = aquatic hyphomycete (excluded!)

Centrospora asiminae (Ell. & Morg.) Deighton, Myc. Pap. 124, p. 5 (1971), *Mycocentrospora asiminae* (Ell. & Morg.) Deighton, Taxon 21, p. 716 (1972) = *Miuraea asiminae* (Ell. & Morg.) v. Arx, Proc. Kon. Nederl. Akad. Wet. C, 86(1), p. 39 (1983)

Centrospora cantuariensis (Salm. & Worm.) Deighton, Myc. Pap. 124, p. 5 (1971), *Mycocentrospora cantuariensis* (Salm. & Worm.) Deighton, Taxon 21, p. 716 (1972) = *Pseudocercospora cantuariensis* (Salm. & Worm.) U. Braun comb.nov. (Bas.: *Cercospora cantuariensis* Salmon & Wormald, J. Bot. Lond. 61, p. 134, 1923). *C. cantuariensis* is a very unusual, abnormal species with extremely broad conidia. But because of the coloured conidiophores, conidia and unthickened conidial scars, I prefer to place this species in *Pseudocercospora*.

Centrospora mitragynae Pavgi, Singh & Deighton, in Deighton, Myc. Pap. 124, p. 11 (1971) and Sydowia 24(1-6), p. 113 ("1970", 1971), *Mycocentrospora mitragynae* (Pavgi, Singh & Deighton) Deighton, Taxon 21, p. 716 (1972) = status unclear (*Pseudocercosporella ochracea* Singh, described on *Mitragyna parviflora* from India, resembles *Mycocentrospora mitragynae*. Because of superficial secondary hyphae and faintly coloured stromata, conidiophores and conidia, this species seems to belong to *Pseudocercospora*. But both species should be re-examined and compared.

Centrospora gracilis Matsushima, Icon. Microfung. Matsush. lect., p. 21, Kobe 1975 = *Cylindrosympodium gracile* (Matsushima) Kendrick & Castañeda, Univ. Waterloo Biol. Ser. 32, p. 9 (1990)

Centrospora helminthosporioides Matsushima, l.c., p. 22, on dead *Podocarpus* leaves, Japan = status unclear!

Mycocentrospora fusarioides Matsushima, Matsush. Mycol. Mem. 5, p. 20 (1987), on dead rachis of *Alsophila*, Taiwan = status unclear!

Mycocentrospora camelliae Deighton, Myc. Pap. 151, p. 6 (1983), basionym = *Pseudocercospora camelliae* (Deighton) U. Braun comb. nov. Conidiophores and conidia are olivaceous and the conidial scars are unthickened. Therefore, this species should be referred to *Pseudocercospora*.

Mycocentrospora cladosporioides (Sacc.) P. Costa ex Deighton, Myc. Pap. 151, p. 6 (1983) = *Pseudocercospora cladosporioides* (Sacc.) U. Braun comb. nov. (Bas.: *Cercospora cladosporioides* Sacc., Michelia 2, p. 556, 1882). Type material of this species is not preserved in PAD, but I could examine another specimen from Saccardo's herbarium (on *Olea europaea*, Tunisi, 20-11-1926, M. Chabeolin, PAD, neotype!). Superficial mycelium, conidiophores and conidia are olivaceous brown and the conidial scars are unthickened, not darkened (fig. 5). A record of "*Cercospora cladosporioides*" on *Prunus laurocerasus* from the USA (Lafayette, La., 1889, Ell. & Ev., North Am. Fung. 2472, fig. 6) does not belong to the present species. The leaves are rotten and the fungus in question is a *Stenella*, possibly identical with *Stenella anomoconis* de Hoog & Boekhout in de Hoog et al. (1983, p. 487).

Mycocentrospora varians Sinclair & Morgan-Jones, Mycotaxon 9(2), p. 472 (1979) = aquatic hyphomycete (excluded!)

Mycocentrospora clavata Iqbal, Biologia (Lahore) 20(1), p. 3 (1974) = aquatic hyphomycete (excluded!)

Mycocentrospora trichophila (J. J. Davis) U. Braun, Nova Hedwigia 56(3-4), in press (1993) = *Pseudocercosporella trichophila* (J. J. Davis) U. Braun comb. nov. (Bas.: *Cercosporella trichophila* J. J. Davis, Trans. Wis. Acad. Sci. Art. Lett. 18, p. 266, 1915).

(3) *Mycovellosiella* Rangel

Mycovellosiella acalyphae (Tharp) U. Braun comb. nov.

Bas.: *Ramularia acalyphae* Tharp, Mycologia 9, p. 120 (1917).
Holotype: on *Acalypha lindheimeri*, USA, San Antonio, Texas, 28-9-1915, Tharp (BPI).

Leaf spots amphigenous, subcircular, angular, irregular, ca. 1-5 mm diam., yellowish, brownish, centre finally greyish, margin indefinite or sometimes darker, occasionally with yellowish halo. Caespituli amphigenous, greyish white. Primary mycelium internal, secondary mycelium external, superficial, arising through stomata, 2-5 µm diam., subhyaline to yellowish, greenish, olivaceous or pale yellowish brown, smooth, branched, septate, sometimes with constrictions. Conidiophores solitary, arising from superficial hyphae, 10-50 x 3-5 µm, simple, straight, subcylindric to slightly geniculate-sinuous, 0-1-septate, smooth, concolorous with the mycelium, conidial scars conspicuous, hardly or slightly thickened, somewhat darkened. Conidia catenate, ellipsoid-ovoid, subcylindric, fusiform, 10-50 x 3-5 µm, 0-4-septate, smooth, subhyaline to pale yellowish-greenish, hila slightly thickened, darkened. Fig. 7.

Because of the coloured secondary mycelium, conidiophores and conidia, this species must be placed in *Mycovellosiella*.

Mycovellosiella bauhiniae (Ell. & Ev.) U. Braun comb. nov.

Bas.: *Ramularia bauhiniae* Ell. & Ev., Ann. Rep. Missouri Bot. Gard. 9, p. 119 (1898).

Holotype: on *Bauhinia divaricata*, Port Morant, Bogwalk, Jamaica, 17-12-1890, Hitchcock (NY).

Leaf spots almost absent or only diffuse, pale yellowish-ochraceous to yellowish-brown discolorations on the upper leaf surface, hypophyllously greyish-white by fructification. Primary mycelium internal, subhyaline, secondary mycelium external, superficial, ca. 1-3.5 µm wide, smooth, septate, branched, subhyaline to faintly yellowish-greenish, pale olivaceous. Conidiophores solitary, arising from superficial hyphae, lateral or terminal, 10-35 x 2.5-5 µm, simple, straight and subcylindric to geniculate-sinuous, 0-3-septate, smooth, concolorous with the mycelium, conidial scars thickened and darkened. Conidia catenate, ellipsoid, fusiform, subcylindric, obclavate, 10-25 x 2-5 µm, (0-) 1-2 (-3)-septate, smooth, concolorous with the conidiophores, hila slightly thickened, darkened. Fig. 8.

The habit of this fungus is *Mycovellosiella*-like and all structures are not quite colourless. Therefore, I prefer to place this species in *Mycovellosiella*.

Mycovellosiella delicatissima (Kalchbr. & Cooke) U. Braun comb. nov.

Bas.: *Cercospora delicatissima* Kalchbr. & Cooke, Grevillea 9, p. 24 (1881).

Syn.: *Cercosporella delicatissima* (Kalchbr. & Cooke) Chupp, A monograph of the fungus genus *Cercospora*, p. 590, Ithaca, New York 1954.

Lectotype: on *Privia leptostachya*, South Africa, in sylvis Mt. Boschberg, Somerset East, 1875, MacOwan 1109 (B). (Lecto-) Isotype: K.

Leaf spots amphigenous, dull brownish, angular-irregular, occasionally almost diffuse, ca. 1-5 mm diam., margin indefinite, spots occasionally confluent and larger. Colonies hypophyllous, inconspicuous. Primary mycelium internal, subhyaline, occasionally forming small hyphal aggregations in the substomatal cavities, subhyaline, pale olivaceous to yellowish brown, secondary mycelium superficial, arising through stomata, sometimes forming ropes or climbing the leaf hairs, septate, branched, ca. 1-3 µm diam., hyaline to pale greenish, yellowish, smooth. Conidiophores solitary, arising from superficial hyphae, lateral or terminal, ca. 5-30 x 1.5-5 µm, simple, usually aseptate, straight and subcylindric to slightly geniculate-sinuous, hyaline to pale olivaceous or yellowish brown, smooth, conidial scars conspicuous, slightly thickened, darkened, solitary or in groups. Conidia formed singly, narrowly ellipsoid-ovoid, fusiform, acicular-obclavate, ca. 10-50 x (1-) 1.5-3 µm, 0-5-septate, smooth, hyaline to pale yellowish-greenish, hila very minute, slightly thickened and darkened. Fig. 9.

This species is a typical *Mycovellosiella* with coloured secondary mycelium, solitary conidiophores and thickened conidial scars.

Mycovellosiella dulcamarae (Peck) U. Braun comb. nov.

Bas.: *Ramularia dulcamarae* Peck, Ann. Rep. N.Y. State Mus. 33, p. 30 (1880).

Syn.: *Cercospora dulcamarae* (Peck) Ell., J. Myc. 1, p. 55 (1885).

Holotype: on *Solanum dulcamara*, USA, Verona, N.Y., Aug., Peck (NYS).

This species forms well developed secondary mycelium with solitary conidiophores, lateral and terminal, and thickened, darkened conidial scars (fig. 10). All structures are coloured. Hence, *R. dulcamarae* belongs to *Mycovellosiella*. Chupp (1954) described this species in detail.

Mycovellosiella isotomae (Cif.) U. Braun comb. nov.

Bas.: *Ramularia isotomae* Cif., Ann. Myc. 30, p. 292 (1932).

Lectotype: on *Isotoma longiflora,* Valle del Ciboa, Prov. Duarte, Cotui, shore of Rio Yuna, 15-4-1930, Ciferri, Mycofl. Doming. Exs. 79 (BPI).

Leaf spots almost absent to diffuse, sometimes subcircular, 2-5 mm diam., yellowish, greyish white, greyish brown, margin indefinite. Caespituli amphigenous, mainly hypophyllous, punctiform to subeffuse, brownish. Primary mycelium internal, forming small, substomatal hyphal aggregations (stromata), brown, secondary mycelium external, superficial, arising through stomata, 1-5 µm wide, septate, branched, hyaline to faintly coloured, smooth. Conidiophores arising through stomata, in loose, divergent fascicles or solitary, from superficial hyphae, lateral or terminal, ca. 15-60 x 2.5-6 µm, straight and subcylindric to geniculate-sinuous,

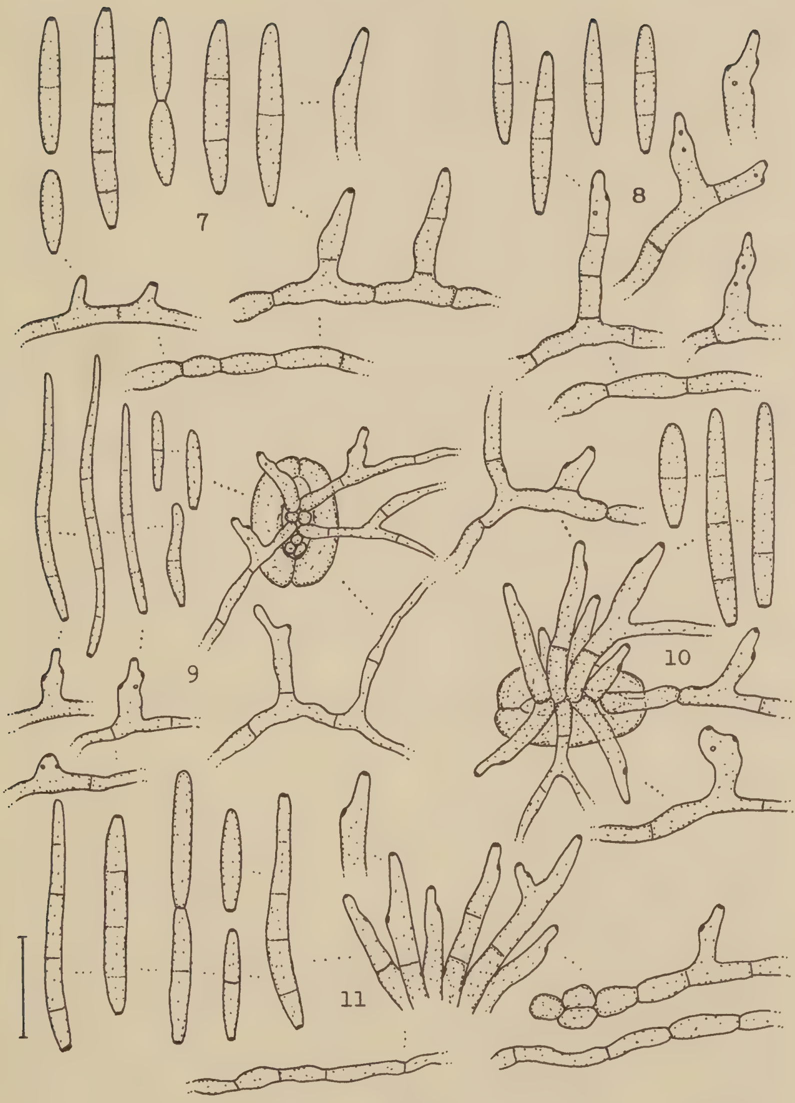

Fig. 7-11. Conidiophores, fascicles, conidia, superficial hyphae, 7 - *Mycovellosiella acalyphae*, 8 - *M. bauhiniae*, 9 - *M. delicatissima*, 10 - *M. dulcamarae*, 11 - *M. isotomae*. Scale - 20 µm. U. Braun del.

simple or branched, continuous to septate, smooth, subhyaline, yellowish brown to medium brown, conidial scars thickened and darkened. Conidia solitary or catenate, subcylindric, fusiform, obclavate, 15-55 x 2-5 µm, 0-4-septate, subhyaline to pale greenish, yellowish, olivaceous, smooth, hila slightly thickened and darkened. Fig. 11.

This species is a typical *Mycovellosiella*.

Mycovellosiella pilophila (Jaczewski ex Vasil'evskij & Karakulin) U. Braun comb. nov.

Bas.: *Ramularia pilophila* Jaczewski ex Vasil'evskij & Karakulin, Parazitnye Nesoveršennye Griby, Č. I, Gifomicety, p. 378, Moskva, Leningrad 1937.

Syn.: *R. pilophila* Jaczewski, in herb.

Holotype: on *Myosotis* spec., Russia, St. Petersburg, 4-10-1919, herb. Jaczewski (LEP).

Infections confined to leaf hairs, primary mycelium internal, secondary mycelium external, superficial, colonies whitish, hyphae ca. 2-6 µm wide, septate, branched, hyaline, greenish, yellowish-green, pale olivaceous, smooth, intertangled, forming loose webs. Conidiophores solitary or in small groups, lateral and terminal, about 10-60 x 2-6 µm, simple, straight, subcylindric to geniculate-sinuous, continuous to septate, smooth, concolorous with the mycelium, conidial scars conspicuous, thickened, darkened. Conidia catenate, occasionally in branched chains, ellipsoid-ovoid, fusiform, subcylindric, 15-35 x 3-6 µm, 0-4-septate, hyaline to faintly greenish-olivaceous, smooth, ends rounded, obconically truncate to subacute, hila slightly thickened. Fig. 12.

The habit of this species is *Mycovellosiella*-like and all structures are not quite colourless. Hence, *R. pilophila* should be placed in *Mycovellosiella*.

Mycovellosiella pirina (Ell. & Ev.) U. Braun comb. nov.

Bas.: *Cercosporella pirina* Ell. & Ev., Proc. Acad. Phil. 1891, p. 91 (1891).

Syn.: *Cercospora pirina* Ell. & Ev., North Am. Fungi 2588 (1891), nom. nud.

Holotype: on *Malus coronaria*, USA, Racine, Wisconsin, 30-8-1890, J. J. Davis (NY).

Leaf spots almost absent, colonies hypophyllous, effuse, whitish, at first in small, irregular patches, later spreading more or less over the entire lower surface, primary mycelium internal, colourless, branched, septate, secondary mycelium superficial, arising through stomata, creeping, 2-5 µm wide, smooth, septate, branched, hyaline to pale yellowish-green, occasionally pale olivaceous. Conidiophores solitary, lateral or terminal, arising from superficial hyphae, ca. 15-30 (-40) x 3-8 µm, simple, straight and subcylindric to geniculate-sinuous, continuous or with a simple septum, smooth, concolorous with the mycelium, conidial scars hardly or only slightly thickened, but conspicuously

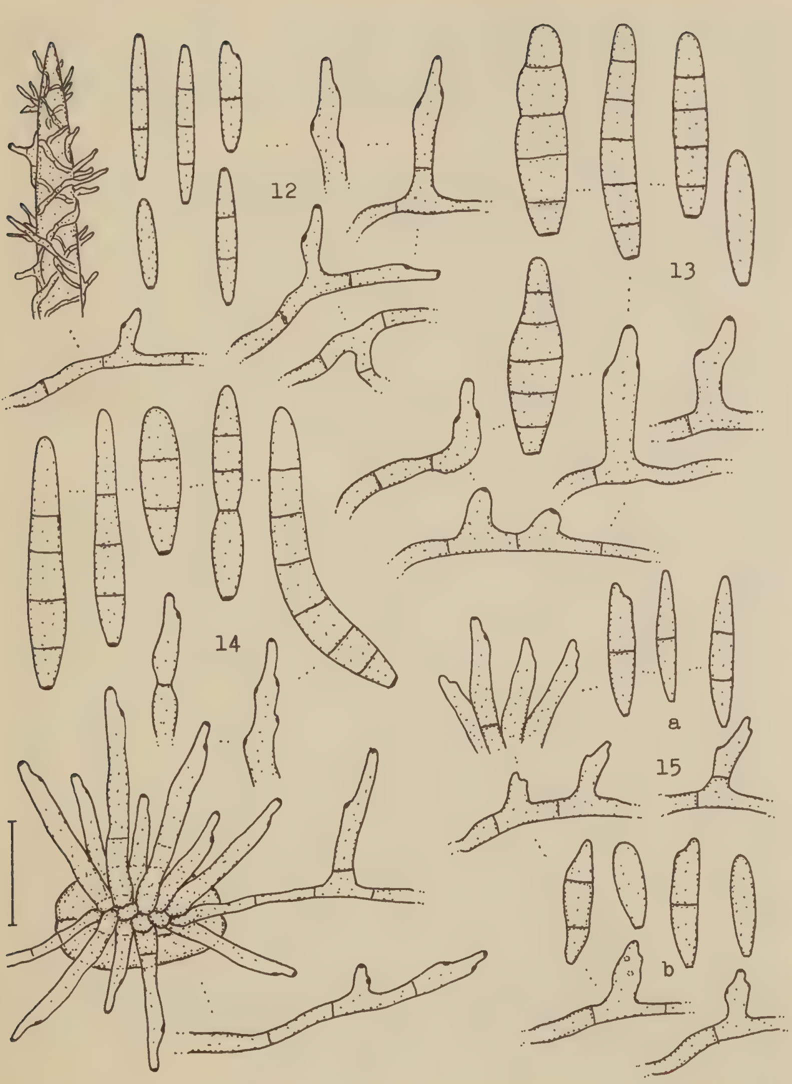

Fig. 12-15. Conidiophores, fascicles, conidia, superficial hyphae, 12 - *Mycovellosiella pilophila*, 13 - *M. pirina*, 14 - *M. pyri*, 15 - *M. subrufa* (a - type of "*Didymaria fulva*", b - type of "*Ramularia dioscoreae*"). Scale - 20 µm. U. Braun del.

darkened. Conidia solitary, subcylindric to broadly obclavate, rarely broadly ellipsoid-ovoid, (15-) 20-50 (-60) x (4-) 5-8 µm, (0-) 3-8-septate, hyaline to faintly greenish, smooth, occasionally somewhat constricted at the septa, apex obtuse, base more or less truncate, hila hardly thickened, but darkened. Fig. 13.

The superficial mycelium, conidiophores and conidia are almost colourless or only faintly coloured. But the habit of this fungus is *Mycovellosiella*-like and the conidia are formed singly. Therefore, this species must be referred to *Mycovellosiella*.

Mycovellosiella pyri (Farlow) U. Braun comb. nov.

Bas.: *Cercospora pyri* Farlow, Appalachia 3, p. 250 (1884).

Syn.: *Cercosporella pyri* (Farlow) Karakulin, in Vassil. & Karakulin, Parazitnye Nesoveršennye Griby, Č. I, Gifomicety, p. 183, Moskva, Lenigrad 1937.

Holotype: on *Aronia arbutifolia*, USA, Shelburne, N.H., Sept. 1883, Farlow (FH).

Leaf spots variable, indistinct, indefinite brownish areas on the upper surface or irregularly shaped brownish spots. Caespituli hypophyllous, not very conspicuous, primary mycelium internal, subhyaline, septate, branched, ca. 1-3 µm wide, stromata absent or only a few swollen hyphae in the substomatal cavities, secondary mycelium external, superficial, sparsely to fairly well developed, arising through stomata, ca. 1.5-3.5 µm wide, hyaline or almost so, smooth, septate, sparsely branched. Conidiophores in small, loose to moderately rich and dense fascicles, arising through stomata, occasionally solitary, from superficial hyphae, lateral and terminal, (5-) 10-60 x 3-8 µm, simple, subcylindric, straight to geniculate-sinuous, occasionally with constrictions, hyaline, subhyaline, occasionally faintly coloured, greenish-olivaceous, especially below, continuous to sparsely septate, smooth, conidial scars conspicuous, hardly thickened, but darkened. Conidia solitary, obclavate, ca. 20-80 x 4-8 (-10) µm, (1-) 2-6 (-10)-septate, hyaline or subhyaline, smooth, occasionally constricted at the septa, apex obtuse, base truncate, hila hardly thickened, somewhat darkened. Fig. 14.

Numerous specimens on *Aronia arbutifolia* and *A. melanocarpa* from Canada and the USA (FH, NY) have been examined. This species is allied to *M. pirina*, but differs by conidiophores in well developed fascicles emerging through stomata and less developed superficial mycelium.

Mycovellosiella subrufa (Ell. & Holw.) U. Braun comb. nov.

Bas.: *Ramularia subrufa* Ell. & Holw., J. Myc. 4, p. 2 (1888).

Holotype: on *Dioscorea villosa* (sub "*Smilax* spec."), USA, Decorah, Iowa, 28-6-1885, Holway (NY).

Syn.: *Ramularia dioscoreae* Ell. & Ev., Proc. Acad. Phil.

1891, p. 85 (1891). Lectotype: on *Dioscorea villosa*, USA, Racine, Wisconsin, 17-8-1889, J. J. Davis (NY). (Lecto-) Isotypes: NY, WIS. *Didymaria fulva* Ell. & Ev., in herb. (valid publication not traced!). Type: on *Dioscorea villosa*, USA, Crawfordsville, Ind., 7-6-1894, Olive (NY). *Pseudocercospora subrufa* (Ell. & Holw.) U. Braun, Crypt. Bot. 3/1, in press (1992).

Leaf spots amphigenous, small, 1-4 mm diam., angular, irregular, vein-limited, yellowish-ochraceous to pale brown, finally sometimes greyish white, margin indefinite or occasionally with darker marginal line, colonies hypophyllous, greyish white to faintly coloured, yellowish-ochraceous, primary mycelium internal, forming small to moderately large stromata, substomatal, occasionally somewhat erumpent, secondary mycelium external, superficial, often climbing leaf hairs, well developed, branched, septate, smooth, ca. 1-4 µm wide, subhyaline to faintly olivaceous. Conidiophores solitary, arising from superficial hyphae or fasciculate, through stomata, from stromata, fascicles small to rich, loose, somewhat divergent to dense, conidiophores ca. 6-60 x 2-5.5 µm, simple, rarely branched, straight and subcylindric to geniculate-sinuous, continuous or sparsely septate, smooth, subhyaline to faintly yellowish-greenish, olivaceous, conidial scars unthickened, not or only slightly darkened, often somewhat protuberant (subdenticulate). Conidia solitary, occasionally catenate, rarely in branched chains, ellipsoid-ovoid, fusiform, straight to curved, (10-) 15-30 (-35) x 2.5-6 µm, subhyaline to faintly yellowish-greenish, pale olivaceous, (0-) 1-2 (-3)-septate, apex rounded to subacute, base obconically truncate, hila ca. 1-1.5 µm wide, unthickened, not or hardly darkened. Fig. 15.

Owing to unthickened, not or hardly darkened conidial scars, Braun (1992) referred *R. subrufa* to *Pseudocercospora* and stated that it is a very unusual species with *Ramularia*-like conidia. *Ramularia subrufa, R. dioscoreae* and *Didymaria fulva* are conspecific. Type host of the three species is *Dioscorea villosa*. The stromata are yellowish brown to brown and hyphae, conidiophores and conidia turn to yellowish green or pale olivaceous with age. Hence, this species must be excluded from *Ramularia*. The conidial scars are often somewhat protuberant (subdenticulate), but unthickened. Pons & Sutton (1988) described *Ramularia dioscoreae* with inconspicuous conidial scars. The conidial scars are, however, not quite inconspicuous. They are unthickened, but often slightly darkened. This unusual species is intermediate between *Pseudocercospora* and *Mycovellosiella*. Because of the *Mycovellosiella*-like habit and *Ramularia*-like, partly catenate conidia, it should better be placed in *Mycovellosiella*.

(4) *Passalora* Fr. (incl. *Cercosporidium*)

Passalora astragali (Ell. & Ev.) U. Braun var. *epiphylla* (Ell.) U. Braun comb. nov.

Bas.: *Ramularia desmodii* var. *epiphylla* Ell., in Sacc., Syll. Fung. IV, p. 203 (1886).

Holotype: on *Astragalus* spec., USA, Wisconsin, Trelease No. 8 (NY).

Braun (1992) transferred *Ramularia astragali* Ell. & Ev. to *Passalora*. This species is somewhat intermediate between *Ramularia* and *Passalora*, but mature conidiophores are always yellowish, greenish to pale olivaceous and the conidia are formed singly. The subhyaline conidia are (12-) 15-20 (-22) x 5-10 µm, 0-1-septate. Var. *hypophylla* differs by longer, slender conidia, 12-32 x 3.5-6 µm, with 1-3 septa. The conidiophores are fasciculate, up to 80 x 6 µm (fig. 16).

Passalora chionea (Ell. & Ev.) U. Braun comb. nov.

Bas.: *Cercospora chionea* Ell. & Ev., Bull. Torrey bot. Club 11, p. 122 (1884).

Syn.: *Cercosporella chionea* (Ell. & Ev.) Sacc., Syll. Fung. X, p. 564 (1892).

Lectotype: on *Cercis canadensis*, USA, Manhattan, Kansas, July 1884, Kellerman (NY). (Lecto-) Isotypes: Rabenh., Fungi eur. 3789 and Ell. & Ev., North Am. Fungi 1515.

This species forms small to rich fascicles of conidiophores, usually erumpent through the cuticle. The conidiophores are about 10-50 x 4-9 µm, subhyaline, pale greenish to olivaceous. The conidia are 40-85 (-100) x 4-7 µm, acicular-subcylindric, obclavate, subhyaline, 3-6-septate (fig. 17). The conidial scars are hardly thickened, but somewhat darkened (*Passalora* type, cf. Deighton 1990, Braun 1992). A full description of this species was published by Chupp (1954, p. 293).

Passalora oleacearum (Chiddarwar) U. Braun comb. nov.

Bas.: *Cercospora oleacearum* Chidd., Ind. Phytopathol. 12, p. 120 (1959).

Examined material: on *Ligustrum japonicum*, China, Schan-Tung, Tsingtau, garden, 1910, Krug (B).

Leaf spots amphigenous, subcircular to somewhat irregular, 2-10 mm diam., ochraceous to pale brownish, margin narrow, often somewhat raised, dark, purplish-violet to blackish, spots often somewhat zonate, occasionally with diffuse purplish halo. Caespituli hypophyllous, dark, punctiform, mycelium internal, stromata small, ca. 10-30 µm diam., brown. Conidiophores solitary or in small fascicles (ca. 2-15), 10-40 x 2.5-7 µm, simple, straight, subcylindric to slightly geniculate-sinuous, aseptate, olicaceous brown, smooth, conidial scars hardly thickened, but somewhat darkened. Conidia solitary, obclavate, rarely subcylindric-fusiform, (25-) 35-50 (-55) x 4-7 µm, 1-3-septate, smooth, faintly coloured, apex obtuse, base obconically truncate. Fig. 18.

This species is a typical *Passalora* with hardly thickened, but darkened conidial scars and broad conidia with few septa.

(5) *Phaeoisariopsis* Ferr.

Phaeoisariopsis elata (Sacc.) U. Braun comb. nov.

Bas.: *Cercosporella elata* Sacc., Ann. Myc. 8, p. 339 (1910).

Holotype: on *Chasmanthera dependens*, Eritrea, Hamasen, Ghinda-Boresa, 27-1-1909, A. Fiori (PAD).

Leaf spots amphigenous, small, angular, irregular, often vein-limited, ca. 0.5-2 mm diam., sometimes confluent, greyish brown to almost blackish, margin indefinite, mycelium internal. Conidiomata hypophyllous, greyish white, ochraceous, pale brownish, numerous conidiophores arranged in dense synnematal fascicles, ca. 150-250 μm long, brown, paler above, free, fertile end subhyaline, greenish to pale olivaceous, individual conidiophores ca. 2-6 μm wide, septate, smooth, subhyaline, greenish to olivaceous, fertile portion strongly geniculate, conidial scars situated on small shoulders, hardly or only slightly thickened and darkened. Conidia solitary, obclavate, ca. 30-80 x 5-9 μm, (1-) 2-4-septate, smooth, subhyaline to greenish, pale olivaceous, apex rounded to subacute, base subtruncate, hila hardly thickened, but somewhat darkened. Fig. 19.

Because of the synnematal conidiophores and hardly thickened, but somewhat darkened conidial scars, this species must be placed in *Phaeoisariopsis*.

(6) *Phaeoramularia* Muntañola

Phaeoramularia momordicae (Heald & Wolf) U. Braun comb. nov.

Bas.: *Ramularia momordicae* Heald & Wolf, Mycologia 3, p. 22 (1911).

Holotype: on *Momordica balsamina*, USA, Falfurrias, Texas, 14-9-1909, Heald & Wolf (BPI).

Leaf spots subcircular to irregular, pale, yellowish-ochraceous, brownish, later greyish white, ca. 1-10 mm diam. Caespituli amphigenous, punctiform to dense, brownish. Mycelium internal, olivaceous brown, septate, branched, forming small substomatal stromata, ca. 10-30 μm diam., olivaceous brown. Conidiophores fasciculate, fascicles small to fairly rich, arising from stromata, through stomata, usually loose and divergent, conidiophores flexuous, geniculate-sinuous, ca. 10-50 x 3-5 μm, olivaceous brown, simple, occasionally branched, smooth, continuous to septate, conidial scars conspicuous, thickened and darkened. Conidia catenate, occasionally in branched chains, subcylindric, ca. 20-80 x 3-5 μm, 0-7-septate, subhyaline to olivaceous or pale olivaceous brown, smooth, hila slightly thickened and darkened. Fig. 20.

The conidiophores and conidia are coloured, the conidia are formed in chains and the conidial scars are thickened and darkened. Hence, this species must be included in *Phaeo-*

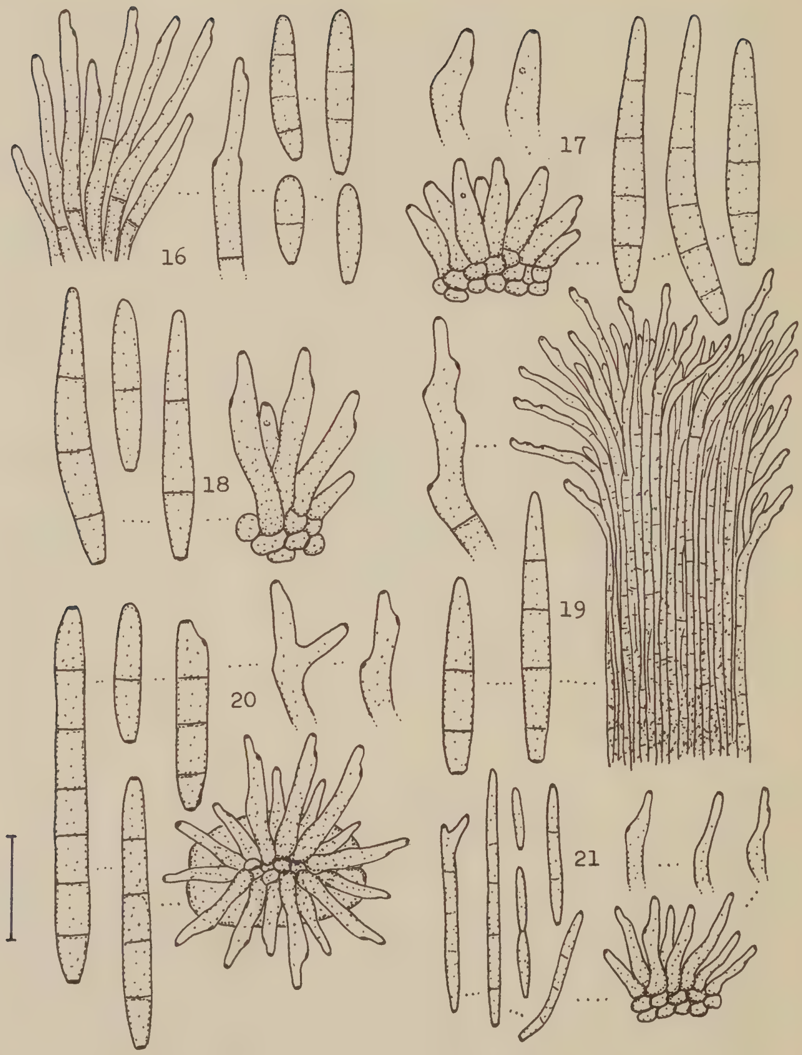

Fig. 16-21. Conidiophores, fascicles, synnema, conidia, 16 - *Passalora astragali* var. *epiphylla*, 17 - *P. chionea*, 18 - *P. oleacearum*, 19 - *Phaeoisariopsis elata*, 20 - *Phaeoramularia momordicae*, 21 - *P. viburni*. Scale - 20 µm. U. Braun del.

ramularia.

Phaeoramularia viburni (Ell. & Ev.) U. Braun comb. nov.

Bas.: *Ramularia viburni* Ell. & Ev., J. Myc. 5, p. 69 (1889).

Lectotype: on *Viburnum lentago*, USA, Racine, Wisconsin, 17-6-1888, J. J. Davis (NY). (Lecto-) Isotypes: NY, WIS.

Leaf spots amphigenous, subcircular to angular-irregular, sometimes vein-limited, greyish green to brown, later centre pale, greyish white, with darker margin, ca. 2-10 mm diam. Caespituli amphigenous, greyish white to brownish by stromata. Mycelium internal, pale, forming well developed stromata in the epidermal cells, rarely substomatal, ca. 10-50 µm diam., occasionally confluent, larger, pale yellowish brown to medium brown, cells ca. 2-6 µm diam. Conidiophores fasciculate, arising from stromata, few to numerous, loose to fairly dense, 5-25 x 2-4 µm, simple, subcylindric, straight to geniculate-sinuous, continuous, occasionally with a single septum, smooth, hyaline to yellowish, greenish, pale olivaceous or yellowish brown, especially below, conidial scars very minute, fairly inconspicuous (very minute, slightly darkened dots). Conidia solitary or catenate, shape and size variable, narrowly ellipsoid-ovoid, fusiform, subcylindric, 8-45 x 1.5-4 µm, 0-4-septate, hyaline to very pale yellowish, greenish, smooth to faintly rough, hila minute, very slightly thickened and darkened. Fig. 21.

This species is unusual. Because of the brown stromata, faintly coloured conidiophores and catenate conidia, it is placed in *Phaeoramularia*. The conidia are, however, almost hyaline and the conidial scars are fairly inconspicuous (very minute, only slightly darkened).

(7) ***Pseudocercospora*** **Speg.**

Pseudocercospora asphodelina (Sacc.) U. Braun comb. nov.

Bas.: *Septoria asphodelina* Sacc., Syll. Fung. III, p. 571 (1884).

Holotype: on *Asphodelus albus*, Belgium, R. P. Cl. Dumont (BR).

Syn.: *Septoria asphodeli* Westendorp, Bull. Acad. Roy. Belg., ser. II, 12(7), p. 573 (1857), non *S. asphodeli* Mont., Ann. Sci. Nat., bot., 11, p. 48 (1849). *Cylindrosporium asphodeli* Kuhnholtz-Lordat & Barry, Bull. Soc. myc. Fr. 65, p. 126 (1949), type - on *Asphodelus cerasifer*, France, Hérault, Garrigue de la Gardiole, près Fabrègues, 11-5-1939, Kuhnholtz-Lordat (not seen).

Leaf spots amphigenous, subcircular to irregular, ca. 2-15 mm diam. or confluent and larger, at first yellowish-ochraceous to brownish, later greyish brown, finally greyish white, with darker margin. Caespituli amphigenous, punctiform, dark brown to almost black. Mycelium internal, septate, branched, ca. 1-4 µm wide, subhyaline to faintly coloured, forming well developed substomatal stromata, ca. 25-80 μm diam., brown. Conidiophores arising from stromata, numerous, dense, ca. 10-25 x 2-4 μm, straight, subcylindric to flexuous, pale, subhyaline to greenish, olivaceous, conidiophores largely immersed, hardly or only slightly erumpent through the stomata, conidial scars inconspicuous, unthickened. Conidia solitary, subcylindric-acicular, obclavate, ca. (15-) 20-50 (-60) x 2-4 μm, subhyaline to greenish, smooth, 0-4-septate, apex subacute, base truncate. Fig. 22.

This unusual species is morphologically very close to *Pseudocercosporella*, but because of the brown stromata and faintly coloured conidiophores, I prefer to place it in *Pseudocercospora*. *P. asphodelina* is a typical "*Cercoseptoria*".

Pseudocercospora diospyri-morrisianae (Sawada) ex Goh & Hsieh, Trans. mycol. Soc. R.O.C. 2(2), p. 90 (1987)

Syn. nov.: *Cylindrosporium kaki* Syd., Ann. Myc. 11, p. 116 (1913). Holotype: on *Diospyros kaki*, Japan, Prov. Mutsu, 1-9-1911, Miura (S).

The epithet "*kaki*" is preoccupied in *Pseudocercospora* (*P. kaki* Goh & Hsieh, 1990, p. 109-110). The type material of *C. kaki* agrees well with the description and illustration of *P. diospyri-morrisianae*. Superficial mycelium with secondary conidiophores is well developed. The conidiophores are 3-20 x 2-4 μm, 0-1-septate, and the conidia are acicular-obclavate, 15-50 x 1.5-3 μm. All structure are subhyaline to faintly coloured. Fig. 23.

Pseudocercospora valerianae (Solheim) U. Braun comb. nov.

Bas.: *Cercoseptoria valerianae* Solheim, Univ. Wyom. Publ. 24, p. 52 (1960).

Lectotype: on *Valeriana edulis*, USA, Grand Teton Nat. Park, Wyoming, 9-8-1957, Solheim, Mycofl. Saximont. Exs. 1192 (CUP 1192). (Lecto-) Isotypes: Mycofl. Saximont. Exs. 1192.

Leaf spots amphigenous, subcircular to angular, irregular, subdiffuse, pale, yellowish-ochraceous, brownish, dull greyish, margin indefinite, 1-10 mm diam., elongated or confluent patches sometimes larger. Caespituli amphigenous, punctiform, dark, dull blackish, often dense, patches finally dark by confluent caespituli. Mycelium internal, stromata substomatal, ca. 20-50 μm diam., olivaceous brown. Conidiophores in dense, rich fascicles, arising from stromata, through stomata, 5-25 (-30) x 2-5 μm, simple, straight to curved, subcylindric to slightly geniculate-sinuous, continuous, pale olivaceous, smooth, conidial scars inconspicuous, unthickened. Conidia solitary, acicular-subcylindric, 50-90 (-100) x 2.5-5.5 μm, 0-4-septate, subhyaline to faintly yellowish-greenish, smooth, apex obtuse to subacute, base truncate. Fig. 24.

Stromata and conidiophores are coloured. Hence, this species must be referred to *Pseudocercospora*. *Cercoseptoria* should be considered a synonym of *Pseudocercospora* (Deighton

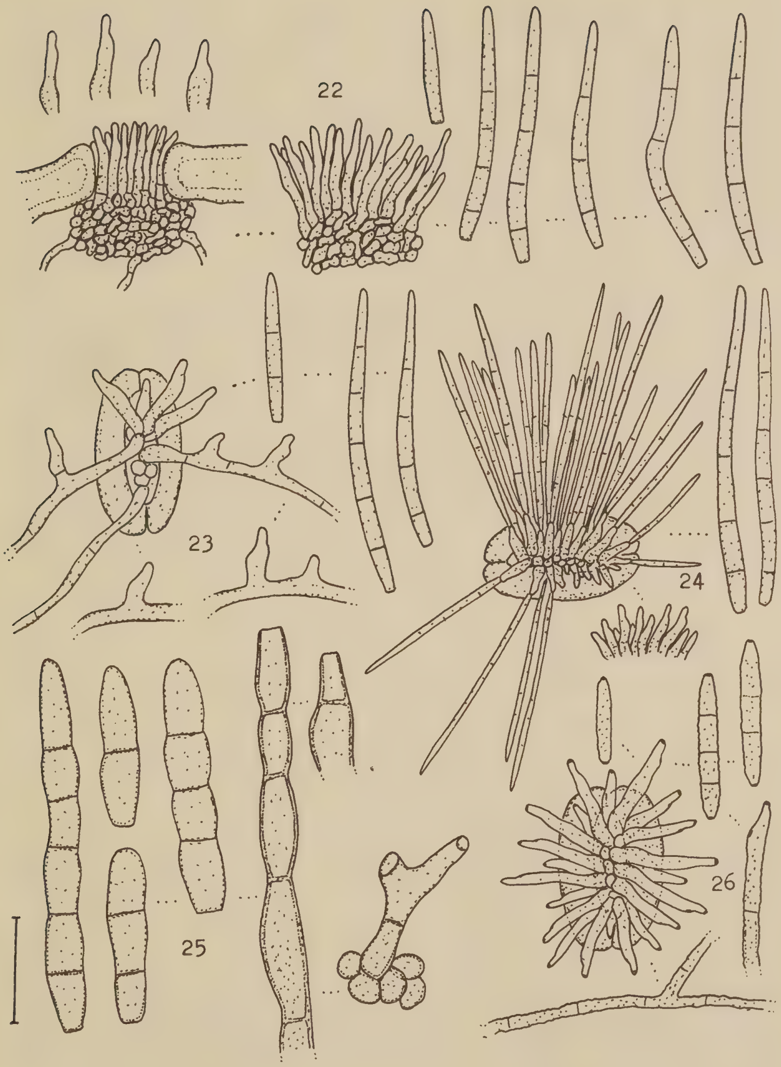

Fig. 22-26. Conidiophores, fascicles, conidia, superficial hyphae, 22 - *Pseudocercospora asphodelina*, 23 - *P. diospyri-morrisianae* (type of *Cylindrosporium kaki*), 24 - *P. valerianae*, 25 - *Sporidesmium olivascens*, 26 - *Stenella sardoa*. Scale - 20 µm. U. Braun del.

1987). Most *Cercoseptoria* species belong to *Pseudocercospora*, some other species to *Pseudocercosporella*. *Cercoseptoria crepidis* Solheim is an exception. This species is a true *Septoria* with small pycnidial to cupulate conidiomata and filiform-acicular conidia (ca. 23-43 x 1.5-3.5 µm): *Septoria crepidicola* U. Braun nom. nov. (Bas.: *Cercoseptoria crepidis* Solheim, Univ. Wyoming Publ. 24, p. 51, 1960, non *Septoria crepidis* Vestergr., Bih. K. Svensk. Vet. Akad. Handl. 22, p. 24, 1896). Type material of *C. crepidis* was distributed as "Solh., Mycofl. Saximont. Exs. 1190" (lectotype: CUP).

Pseudocercospora viticicola U. Braun nom. nov.

Bas.: *Cercospora viticis* Ell. & Ev., J. Myc. 3, p. 18 (1887), non *Pseudocercospora viticis* Goh & Hsieh (1989).
Syn.: *Pseudocercosporella viticis* (Ell. & Ev.) Gupta & Kamal (1989, p. 388).
Holotype: on *Vitex agnus-castus*, USA, 21-9-1886, Langlois No. 727 (NY).
Gupta & Kamal (1989) placed this species in *Pseudocercosporella*, but *C. viticis* is characterized by brown stromata and faintly coloured conidiophores and conidia. Hence, this species must be referred to *Pseudocercospora*. *P. viticis* Goh & Hsieh differs by well developed superficial mycelium with secondary conidiophores. The latter species is hardly distinct from *P. vitici-quinatae* (Yen) Yen (1978).

(8) *Sporidesmium* Link: Fr.

Sporidesmium olivascens (Thüm.) U. Braun comb. nov.

Bas.: *Septocylindrium olivascens* Thüm., Myc. Univ., cent. 16, No. 1570, Klosterneuburg 1880 (with description!).
Lectotype: on *Elaeagnus angustifolius*, France, Lyon, botanical garden, Sept. 1879, Therry, Thüm., Myc. Univ. 1570 (HAL). (Lecto-) Isotypes: Thüm., Myc. Univ. 1570.
Leaf spots epiphyllous, not very conspicuous, subcircular to elliptic, ca. 1-3 mm diam., olivaceous, brownish, margin indefinite. Colonies epiphyllous, effuse, mycelium internal as well as external, brown, septate, branched, ca. 2.5-6 µm wide, small aggregations of brown, subglobose, swollen cells often present. Conidiophores erect, solitary or in small groups, long, up to 150 x 5-15 µm, simple, brown, smooth, septate, frequently with constrictions, conidiogenous cells terminal, monoblastic, determinate. Conidia solitary, subcylindric, ellipsoid-ovoid, subclavate, obclavate, 30-90 x 7-16 µm, 1-5-septate, smooth, brown, apex rounded, base truncate, often with constrictions. Fig. 25.

(9) *Stenella* Syd.

Stenella sardoa (Sacc.) U. Braun comb. nov.

Bas.: *Ramularia sardoa* Sacc., Ann. Myc. 1, p. 443 (1903).

Holotype: on *Paeonia corallina*, Italy, Sardegna, 1895, Martelli (PAD).

On fading leaves, spots amphigenous, angular, irregular, sometimes vein-limited, ca. 2-8 mm diam. or confluent and larger, dull brown to dark greyish brown, margin indefinite. Primary mycelium internal, forming small to well developed substomatal stromata, subhyaline to faintly coloured, secondary mycelium superficial, arising through stomata, 1-3.5 µm wide, subhyaline, greenish to pale olivaceous, verruculose. Conidiophores fasciculate, arising from stromata, through stomata, fascicles small and loose to rich and fairly dense, conidiophores straight, subcylindric to moderately geniculate-sinuous, 8-50 x 2-4.5 µm, simple, continuous or sparsely septate, subhyaline, greenish to pale olivaceous, smooth to verruculose, conidial scars conspicuous, thickened and darkened. Conidia catenate, rarely in branched chains, more or less cylindric, ca. (20-) 25-35 x 3-5 µm, verruculose, subhyaline to faintly greenish, hila slightly thickened and darkened. Fig. 26.

This species forms verruculose superficial hyphae. The mycelium and the conidiophores are faintly coloured and the conidia are coarsely verruculose. Therefore, I prefer to place *R. sardoa* in *Stenella*. The relation of this species to *Ramularia paeoniae* Vogl. (Ann. R. Acc. Agr. Torino 48, p. 449, 1905) is unclear. Type material of the latter species was not available.

Acknowledgements

I wish to convey my thanks to the curators of the herbaria B, BP, BPI, CUP, FH, K, LEP, NY, NYS, PAD, S and WIS for allowing me to examine type specimes in their keeping. I am indebted to Dr. C. T Rogerson (New York) for his critical review of the manuscript.

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MYCOTAXON

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A NEW SUBSTRATE FOR STROBILURUS CONIGENOIDES (ELLIS) SINGER

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Agaricus conigenoides was first described by Ellis (1876), then later transferred to *Strobilurus* by Singer (1962). Basidiocarps of this species are whitish with an ochraceous buff disc and measure 3-15 mm broad. They fruit from September to November and have been reported from New Jersey to Florida, west to Texas. Although *S*. *conigenoides* has been reported as *Collybia conigenoides* (Ellis) Sacc. on various substrates, including conifer cones, it has only been documented with certainty from *Magnolia* cones. Most other reports were based on misdeterminations (Redhead 1980). In the southeastern United States *S*. *conigenoides* is very common following periods of heavy rain.

On November 24th, 1991, several basidiocarps in all stages of development, were collected on decomposing Sweetgum (*Liquidambar* *styraciflua* L.) fruit along Spring Creek in the Mercer Arboretum and Botanical Garden, North Harris County, Texas. There are physical similarities in the habitat but the substrate represents a new host family for *S*. *conigenoides* as well as the genus Strobilurus; hence, the observation is significant scientifically. Collections were sent to Dr. Scott Redhead who confirmed their identification.

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CRESPONEA A NEW GENUS OF LICHENIZED FUNGI IN THE ORDER ARTHONIALES (ASCOMYCOTINA)

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Abstract: The new lichen genus *Cresponea* Egea & Torrente (Arthoniales, lichenized Ascomycetes), is described with *C. premnea* (Ach.) Egea & Torrente as type species. It includes eleven species and one variety, as well as thirteen new synonyms, formerly placed in *Lecanactis* Körber (type species *L. abietina* (Ach.) Körber). Studies of morphology and anatomy show that these are a homogeneous group of closely related species which differ significantly from taxa included in *Lecanactis*. A key to the species involved are given as well as details of morphology, anatomy, taxonomy, distribution and habitat.

Introduction

The lichen genus *Cresponea* is here proposed as new to accomodate a very homogeneous group of species formerly included in *Lecanactis* Körber. The main characters are: lecideoid ascomata, epruinose margin, carbonaceous excipulum, paraphysoids not or few branched in the hymenium, asci of *Abietina*-type, ascospores hyaline not brown when old, transversaly septatae, with a conspicuous endospore, pycnidia immersed to subimmersed in the thallus, and short, straight microconidia, without macroconidia. Species of *Cresponea* are widely distributed all over the world, but with the major centre of distribution in tropical and subtropical zones.

Acharius (1810) described *Lecidea premnea* Ach. and *L. plocina* Ach., from Angliae (England). Later, Montagne (1851) described *Lecidea leprieurii* Mont., from Nova Granata (Colombia). None of this species was included into *Lecanactis* sensu Eschweiler (1824) or Körber (1855). Massalongo (1860) was the first ones to relate *Lecidea plocina* with *Lecanactis*. Tuckerman (1864) comments, as a closely related group, on the following species: *Lecidea coniochlora* Mont. et v. de Bosch, *L. insignior* Nyl., *L. premnea* var. *plurilocularis* Nyl., *L. proximata* Nyl., *Lecanactis chloro-*

conia Tuck., *L. leprieurii* (Mont.) Tuck., and *L. premnea* (Ach.) Arn. Subsequently, other taxa here considered as *Cresponea* were regarded as *Lecidea* or *Lecanactis*. In Zahlbruckner Catalogus Lichenum Universalis all the taxa related with *Cresponea* were included in *Lecanactis* and this has been generally accepted till now.

The new genus *Cresponea* is named in honour of Dra Ana Crespo (Madrid).

Materials and methods

Type and other material was studied from the following herbaria: B, BCC, BERN, BG, BM, BRA, CBG, FH, G, GZU, H, M, MIN, MUB, NY, O, PC, S, STU, TUR, U, US, UPS, W, and the personal collections of A. Aptroot (Utrecht), J. Hafellner (Graz), M. R. D. Seaward (Bradford) and V. Wirth (Stuttgart). Abbreviations of the herbaria follow *Index Herbariorum* (Holmgren *et al.* 1981).

Sections of thalli and ascomata were mounted in water, 10 % KOH (K), Lugol's solution (I) and lactophenol cotton blue. All measurements indicated were made in water mounts. The iodine reaction of the asci was studied in Lugol's solution after pretreatment with K (K/I). Thin layer chromatography (TLC) of acetone extracts of thalli was carried out using standard methods (Culberson & Kristinsson 1970), and later modifications.

Most of the terms referable to morphological and anatomical structures are used in the sense previously employed by the authors (Torrente & Egea 1989), unless otherwise stated. The phytogeographical categories are basically according to Takhtajan (1986).

The Genus

Cresponea Egea & Torrente gen. nov.

Ascomycetes lichenisati algas trentepohliaceas continentes. Thallus crustaceus, ecorticatus. Ascomata sessilia ad basin constricta, rotundata vel leviter irregularia, margine nigro crassiusculo, prominulo, plus minus crenulato. Discus primum flavescenti-, ochraceo fulvescenti- aut rufescenti-pruinosus, demum nudatus et niger. Excipulum integrum carbonaceum. Paraphysoides leviter ramosae. Asci fissitunicati, octospori. Endoascus structura anulari amyloidea instructus. Ascosporae hyalinae, transversaliter septatae, non halonatae. Endosporio conspicuo.

Holotypus generis: *Cresponea premnea* (Ach.) Egea & Torrente

Thallus crustose (Fig. 1A), continuous, cracked or seldon areolate, with smooth rarely leprose (*C. leprieuroides*) surface, effuse, whitish, greyish or greenish. The thallus is thin, usually poorly developped, endo- to episubstratal, a hypothalline line sometimes forming an irregular black or dark brown border around the thallus. In section appearing

+/_ paraplectenchymatous, ecorticate and without a differentiated medulla. Isidia and soralia absent. In all species the photobiont belongs to the family Trentepohliaceae, probably *Trentepohlia*.

Ascomata apothecioid, sessile, with constricted base, 0,2-2,5 mm in diameter, roundish, scattered or rarely 2-4 together and then slightly contorted through mutual pressure. Occasionaly the ascomata have a central colum of sterile tissue. Margin lecideine, prominent, raised above the level of the disc, smooth (Fig. 1B) or more often denticulate or crenulate (Fig. 1C), persistent glossy black, epruinose. Disc at first usually concave but soon plane to slightly convex, black, covered by a +/_ dense coating of greenish, orangish or reddish pruina, often only present in younger ascomata. Excipulum well developped (Fig. 1D), without algae, dark brown to carbonaceous, K+ dark green or olive brown, composed of conglutinate, thick-walled hyphae; closed at the botton and extending down towards the medulla or substrate; the hyphal walls are strongly gelatinized and the individual hyphae are not easily discerned, only, in some sections, hyphae have been observed in the outer part of the excipulum and they are anticlinally arranged. Hymenium colourless, I+ blue/reddish or reddish, K/I blue, with hymenial strand of excipular tissue intruding between the paraphysoids (ascostromata multiascal, pluricarpocentral, *sensu* Tehler 1990: 2465). Subhymenium (*sensu* Letrouit-Galinou & Bellemère 1989: 191) pale brown or rarely colourless. Paraphysoids hyaline, septate, simple or sparsely branched, with little or no anastomoses, up to 2,5 µm wide; apical cell of paraphysoids clavate, with a distinct pale or dark brown cap which is formed in the outer (Fig. 1G) or seldon in the inner part of the cell wall (Fig. 1f), anticlinally arranged or richly branched and corralloid, forming a granulose, dark brown pseudoepithecium, K+ yellow or rarely purple. Under polarized light the granulations were yellowish to reddish.

Asci bitunicate with fissitunicate dehiscence, clavate to cylindric-clavate, slightly stiped, 8-spored (Fig. 1E). Exoascus thin and refringent; endoascus of varying thickness, according to the stage of development of the ascus, 2-layered, both layers hemiamyloid (K/I+ blue), but in the internal endoascus there is a thick band strongly amyloid, with a easily distinguishable ring structure and a small ocular chambre, without apical nasse (*Abietina* type: Torrente & Egea 1989). Under ME (Bellemère, com. litt.), the wall is thick and distinctly layered; the internal layer (d-layer) present all over the ascus is divided into two thick, and quite distinct sublayers; the external (d_1) sublayer being thinly stratified and the internal (d_2) sublayer being vesiculous.

Ascospores fall between 11 and 85 µm in length (Fig. 2), and between 3 and 9 µm in width, with 3 to 19 transverse septa, oblong-fusiform, fusiform to acicular-fusiform, straight or somewhat curved, thick walled and more or less widened at septa, with smooth surface and without a distinguisable gelatinous sheath, hyaline, rarely brownish when old. Under ME (Bellemère, com. litt.), the wall is composed of a thick, strongly reactive perispore, with vesicles in young ascospores, becoming dense and granulous in mature ascospores; proper wall distinct, somewhat thinner and rather transparent; clear endospore thin at first and then well developed around each cell after ascospore septation.

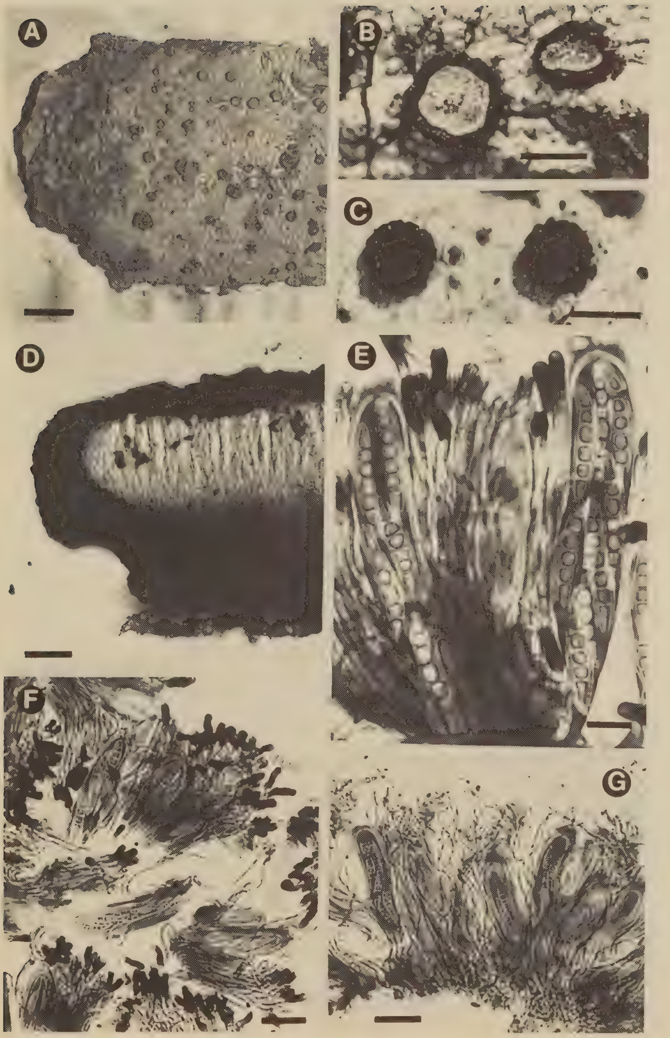
Pycnidia solitary, punctiform, immersed or subimmersed in the thallus, epruinose; in vertical section, they are globose to subglobose, with walls dark brown or carbonaceous at the upper part and colourless to pale brown in the inner part. Conidiophores type I or II (Vobis 1980); Conidiogenous cells in terminal position. Microconidia oblong, straigh and short, 3-5 x 1-1,5 µm. Macroconidia not found.

The ascomata and pycnidia development has been previously pointed out by Torrente & Egea (1989) and Letrouit-Galinou (1984) respectively.

Chemistry: Thallus and medulla K-, C-, KC-, P-. No substances detected by TLC, except in *C. leprieuroides*, which have lecanoric and gyrophoric acids, and its thallus is C+ reddish.

Distribution and habitat: According to our present knowledge, *Cresponea* species are widely distributed between tropical and warm temperate regions of the world. Some species as *C. chloroconia*, reaching cold temperates areas of the Northern Hemisphere. The genus is best represented in the Tropics. Of the twelve taxa treated in this paper, *C. flava* and *C. proximata* are Pantropical. Three additional species occur in the Neotropical Kingdom, *C. follmanii* on the coast of the Andean region in Chile, and *C. melanocheloides* and *C. leprieurii* in the Caribbean and adjacent regions. The last species ranging to USA and Australia. Three species are restricted to the Paleotropical Kingdom, *C. flavescens* in the Uzambara-Zululand region, and *C. leprieuroides* and *C. macrocarpoides* in the Malesian region. *C. chloroconia, C. premnea* var. *saxicola* and var. *premnea* are known from the Holartic Kingdom, the later in the Eurosiberian region and the other two are Circumboreal. *C. plurilocularis* has an Australasian distribution, ranging to some Pacific islands.

Figure 1. *Cresponea*: A-B, *C.proximata* (lectotype); A, Overview of thallus; B, Ascomata. Note the pruinosa disc and the smooth, epruinose margin.- C-F, *C. premnea* (B, *Sipman* 2.9.1971; C, Epruinose ascomata with dentate margin; D, Cross-section of ascoma; E, Asci and paraphysoids; F, Hymenium after squash. Note the simple or sparsely branched paraphysoids and the dark brown cap in the inner part of the apical cells.- G, *C. flavescens* (lectotype). Hymenium after squash. Note the hyaline apical cells of paraphysoids. Scales: A = 5 mm; B-C = 1mm; D = 50 µm; E = 10 µm; F-G = 25 µm. E-G in iodine after pretreatment of K.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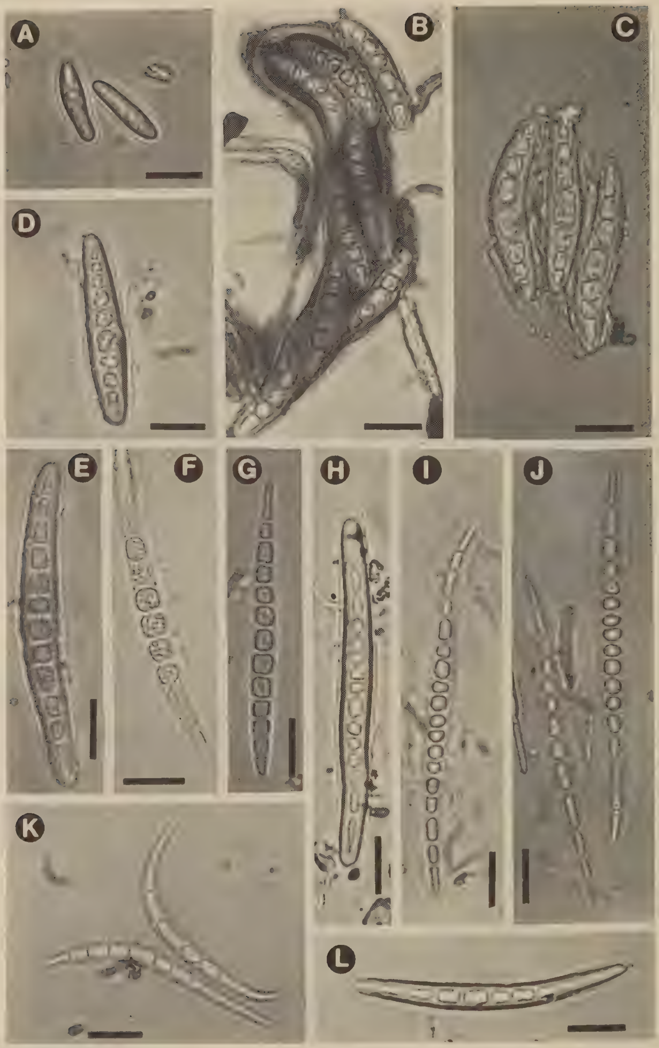
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Most species are found in tropical rainforest, moist forest, or in mangroves at shores as well as on low hills areas. Some taxa as *C. premnea* var. *premnea* occur in deciduous temperate forest or, rarely as *C. chloroconia*, in aciculifolious or mixed forest. They are normaly found on dry, rough, more rarely smooth bark of trees or shrubs, in humid and shaded places. Only *C. premnea* var. *saxicola* is saxicolous and grows on more or less vertical, and ovehanging shaded surfaces.

Notes: The genus *Cresponea* has characters of Arthoniales, and most frequently were referred to *Lecanactis* (type species *L. abietina*) which they resemble in many respects, as: Photobiont of Trentepohliaceae, ascomata roundish, with hymenial strand (*sensu* Tehler 1983: 18), multiascal, pluricarpocentral (sensu Tehler 1990: 2465), no differentiation of a parathecial apparatus (*sensu* Letrouit-Galinou & Bellemère 1989: 213; Torrente & Egea 1989: 47), excipulum lecideine, well developped, hamathecium paraphysoidal, asci bitunicate with a fissitunicate dehiscence, endoascus hemiamyloid, transversally septate ascospores and ascomatal development. *Cresponea* is distinguished from *Lecanactis*, and other allied genera, such as *Opegrapha*, by the combination of the following characters: margin of ascomata, surface of excipular hyphae, granulations of pseudoepithecium, ultrastructure of the asci, spore type and chemistry. The three genera are compared in table 1 and 2.

The different species which make up the genus *Cresponea* show a great regularity of features. For that reason, in many cases it is very difficult to separate some species from others, as previously stated by Tuckerman (1864). Only the size and shape of the ascus, size and number of septa of the ascospores result relevant and useful in this respect. In addition, the colour of apical cells of paraphysoids has been useful as a distinctive character too. Others features such as the thallus, size of ascomata, quantity of pruina colour, or the hymenium and subhymeniun reaction with I, show a wide range of variability among the same species. For that reason, they lack taxonomical value. Even the size of the asci and ascospores, and the number of septa overlap in related species. Therefore, these data should be considered carefully.

The descriptions of the species of *Cresponea* given below do not include the photobiont, paraphysoid, ascus type, and chemistry (except in C. leprieuroides), because they are similar in all specimens investigated.

Figure 2. Ascospore diversity in *Cresponea*: A, *C. chloroconia* (lectotype); B, *C. plurilocularis* (lectotype); C, *C. premnea* var. *premnea* (B, *Sipman* 2.9.1971); D, *C. proximata* (lectotype); E-G, *C. leprieurii* (E-F lectotype of *L. americana*, G lectotype of *L. insignior*); H-J, *C. melanocheloides* (lectotype); K-L, *C. macrocarpoides* (lectotype). Scales = 10 µm. A, D, E, H, L mounted in water; C, F, K after pretreatment of K; B, G, I-J after pretreatment of K/I.

Table 1. Differences between the *Opegrapha vulgata* group, the *Lecanactis abietina* group and *Cresponea*: Ascoma.

	O. vulgata group	*L. abietina* group	*Cresponea*
Shape	Lirelliform	Apothecioid	Apothecioid
Attachment	Immersed to sessile	Sessile	Sessile
Base	Not constricted	Constricted	Constricted
Disc	Slit-line to slightly widened, epruinose	Widened, with whitish, greyish or yellowish, persistent, pruina	Widened, with greenish, orangish or reddish pruina, often epruinose
Margin	Glossy black, smooth, epruinose	Matt, smooth, pruinose	Glossy black, smooth or more often denticulate or crenulate, epruinose
Excipulum:			
Texture in the outer part	Individual hyphae not easily discerned	With radomly, scatered hyphae	Individual hyphae not easily discerned
Surface of hyphae	Smooth, without crystals soluble in K	Verrucose, with crystals soluble in K	Smooth, without crystals soluble in K
Granules (under polarized light)	Absent	Whitish, greyish or brownish, K-, coating the excipulum and pseudoepithecium	Yellowish to reddish, K+ yellow or purpre, coating the pseudoepithecium
Himenial strands*	Absent (monocarpocentral*)	Present (pluricarpocentral*)	Present (pluricarpocentral*)
Paraphysoids	Richly and divergently branched, often anastomosed	Sparsely and irregularly branched, +/- anastomosed	Simples or sparsely branched not or few anastomosed

* Tehler (1990)

Table 2. Differences between the *Opegrapha vulgata* group, the *Lecanactis abietina* group and *Cresponea*: Ascus, ascospores, pycnidia and chemistry.

Ascus:			
Outer endoascus	Non-hemiamyloid	Slightly hemiamyloid	Slightly hemiamyloid
Inner endoascus	Strongly hemiamyloid	Strongly hemiamyloid	Strongly hemiamyloid
Ultraestructure*	Internal "d" layer 2-sublayered, with the internal (d_2) vesiculous	Internal "d" layer not sublayered, and not vesiculous	Internal "d" layer 2-sublayered, with the internal (d_2) vesiculous
Ascospores:			
Shape	Fusiform to acicular	Fusiform or spermatoid	Oblong-fusiform to acicular-fusiform
Septa	5-15	3-7(8)	3-19
Cell wall	Thin walled, not widened at septa	Thin walled, not widened at septa	Thick walled, +/- widened at septa
Gelatinous sheath	Present	Absent	Absent
Ultraestucture*			
Perispore	Thick and strongly reactive	Rather thin, reactive, but vesiculous	Thick and strongly reactive
Endospore	Not differentiate	Not differentiated	Differentiated
Pycnidia:			
Attachment	Immersed to subimmersed	Borne on protuberances	Immersed to subimmersed
Shape (in section)	Globose or subglobose	Cylindric, pyriform, U or V-shaped	Globose or subglobose
Macroconidia	Absent	Present	Absent
Final secondary products	Absent	Schizopeltic and lecanoric acid	Absent or, rarely with lecanoric and gyrophoric acid

* Bellèmere (com. litt.)

Key to species of Cresponea

1. Spores up to 22(-24) µm in length and up to 4(-5) septate. Ascomata less than 0,7(-1) mm in diam. 2
1. Spores longer and more septate. Ascomata usually more than 1 mm in diam. 4
2. Spores 11-17 x 3-4,5 µm, 3 septate. Asci 35-45 µm long. Dark brown cap of the apicall cells of paraphysoids formed in the inner part. Holartic .... 1. **C. chloroconia**
2. Spores more than (14-)16 µm long. Asci 45-60 µm long. Dark brown cap of the apical cells of paraphysoids formed in the outer part 3
3. Asci 10-12 µm wide. Spores 15-20(-22) x 4-4,5 µm. 3(-4) septate. Chile .... 4. **C. follmannii**
3. Asci 13-17 µm wide. Spores 15-22(-24) x (4-)4,5-5,5 µm, 3 to 3-4(5) septate. Pantropical .... 2. **C. flava**
4. Spores up to 7(-8) septate 5
4. Spores more septate 9
5. Thallus C+ reddish. Malacca .... 6. **C. leprieuroides**
5. Thallus C- 6
6. Spores 20-28(-30) µm long. Ascomata 0,3-1 mm in diam.. 7
6. Spores 25-38(-40) x 5-7(-7,5) µm. Ascomata 0,2-1,5(-1,8) mm in diam. Pantropical .... 11. **C. proximata**
7. Dark brown cap of the apical cells of paraphysoids formed in the outer part. Asci 60-70 x 15-16 µm. Mozambique .... 3. **C. flavescens**
7. Dark brown cap of the apical cells of paraphysoids formed in the inner part. Asci 60-80 x 12-15 µm 8
8. Corticolous. Spores 4-5(-5,5) µm wide, 5-7 septate. Europa, Macaronesia ...... 10. **C. premnea var. premnea**
8. Saxicolous. Spores 5-6 µm wide, 4-5(-6) septate. Holartic .... 10. **C. premnea var. saxicola**
9. Spores 63-90 x (5,5-)6-7 µm, up to 19 septate. Neotropical .... 8. **C. melanocheloides**
9. Spores less than 65 µm long, up to 13 septate 10
10. Spores 3,5-5 µm wide. Asci 70-80 x 15-18 µm. Taiwan ... . 7. **C. macrocarpoides**
10. Spores and asci wider 11
11. Spores 30-43(-45) x 6-8(-9) µm, widened at septa. Asci 65 100 x 18-22 µm. Australasia, Malesia .... 9. **C. plurilocularis**
11. Spores (34-)38-65 x 5-7 µm, not widened at septa. Asci 82-95 x 16-27 µm .... 5. **C. leprieurii**

The Species

1. Cresponea chloroconia (Tuck.) Egea & Torrente comb. nov.

(Figures 2A, 3)

Lecanactis chloroconia Tuck., Proc. Amer. Acad. Arts 6: 285 (1864).- *Lecanactis premnea* (Ach.) Arn. var. *chloroconia* (Tuck.) Tuck., Gen. Lich. 194 (1872). **Type:** USA. New Hampshire, Mt. White, in Acere saccharino, juxta ripus fluvi Washingtoniani, 9-1848, *E. Tuckerman* (FH lectotype, selected here).

Lecanactis deminuens (Nyl.) Vain., Bot. Tidsskr. 29: 121 (1909).- *Lecidea premnea* Ach. f. *deminuens* Nyl., Flora 50: 373 (1867). **Type:** Fennia, Tavastia australis, Asikkala. Ad lign. abietis, 1865 ("1866"), *J. P. Norrlin* (H-NYL 10790, lectotype selected here; H-NYL 497, isolectotype).

Lecanactis xanthococcoides Vain. in Ahlqu. Kolemann. tutkim. Länsi-Siperiassa 4: 105 (1928). **Type:** Sibiria occ. Leuschin seutu, Tumynvatsk, ad truncum putridum in abiegno, 1880, *E. Vainio* (TUR-VAIN 26482, lectotype selected here).

Thallus whitish or greenish, continuous with smooth surface, occasionally granulose or indistinct, hypothalline line sometimes forming a thin, dark brown, border around the thallus.

Ascomata numerous, sessile, scattered, roundish, constricted at base, 0,2-0,7(-1) mm in diameter, with a smooth or dentate margin. Disc plane or slightly concave, green pruinose when young, epruinose at maturity. Hymenium 45-70 µm, I+ reddish, K/I+ blue. Subhymenium hyaline, 25-40 µm, I+ slightly blue/reddish or reddish, K/I+ blue. Paraphysoids up to 1,5 µm wide in the hymenium; apical cells thickened (3-4 µm), with a distinct dark brown cap which is formed in the inner part of the cell wall. Asci 35-45 x 10-12 µm at maturity. Ascospores ovate to oblong-fusiform, often somewhat widened at one end, 11-17 x 3-4,5 µm, 3 septate, cell walls slightly thickened at septa, straight or slightly curved.

Pycnidia immersed or subimmersed in the thallus, 100-120 µm tall, 90-100 µm wide. Conidia 3-5 x 1-1,5 µm, straight or slightly curved.

Habitat and distribution: It occurs from warm to cold temperate areas of the Northern hemisphere. It is frequent in USA, mainly in the northern and northeastern states (New Hampshire, New York, Minnesota, Michigan ...). Its area spreads up to northern Canada (Ontario, Manitoba) and western California. It is also known in isolated areas of northern Europe (Finland and Russia). On bark an lignum of coniferous (*Picea, Abies, Cedrus, Taxus* ...) or deciduous (*Acer, Populus, Fraxinus, Quercus*...) trees often in coniferous or mixed forest.

Notes: The size of the asci and ascospores of *Cresponea chloroconia* suggest a close relationship to *C. flava* and *C. follmanii*. However, the former differs in having usually smaller ascospores, asci and hymenium. In addition, in *C. flava* the ascospores are more widened at septa, and in *C. follmanii* mostly of the ascospores are curved. No differences has been noted between *C. chloroconia* and the type material of *Lecanactis deminuens* and *L. xanthococcoides*, described from Europe.

Additional specimens examined: **CANADA:** Ontario: Emo, on cedars in swamps, 10.7.1901, *Fink* (FH, NY, UPS, O), Oakpoint Island east of Kettle Falls at east end of Rainy Lake, on southern part of island in old *Thuja* swamp with areas of ash, 14.6.1978, *C. M. Wetmore* (MIN), 12 Km S of

Smooth Rock Falls (22 Km NW of Cochrane), near logging road in lowland with *Thuja*, some balsam fir and black spruce, 25-6.1982, *C. M. Wetmore* (MIN); Lake Manitoba, 1881, *J. Macoun* (FH).- **RUSSIA:** Mosgna distr. Mozhajsk, in sylva Borissov, 1903, *Elenkin* (O, S, UPS); Ditio Uralensis, Distr. Perm, in silvis prope pag. Oborino, ad corticem Abietis, 1.9.1926, *A. Oxner* (UPS).- **USA: California:** Marin Co., 1 1/2 mi W of Manzanita, on rolling hills of serpentine and sandstone, scattered myrtles, 400 ft., on road to Mt. Tamalpais, on *Umbellaria*, 25.3.1953, *W. A. Weber* (FH); Orange Co., Bluffs near Newport, 6.1911, *H. E. Hasse* (FH), near Newport, on *Isomeris arborea*, 1911, *H. E. Hasse* (FH); San Francisco, 25.10.1892, *W. C. Blasdale* (NY); San Mateo Co., Añonuevo Creek, 11 mi, S. of Pescadero, S of Point Añonuevo, 100 ft., 29.8.1957, *S. Shushan* (UPS), Pescadero, in squamis strobilorum *Pinus insignis*, 1867, *H. N. Bolander* (FH); Santa Monica Mts., St. Ynez Canyon, on bark of dead *Quercus*, *H. E. Hasse* (FH); **Massachuset:** Hadley, on an old chestnut, 1856, *E. Tuckerman* (FH); **Michigan:** Alger Co., Pictured Rocks Nat. Lakeshore, half mile southwest of Hurricane River Campground, back from shore of Lake Superior in low area with *Thuja*, balsam fir, maple and white birch, 15.7.1987, *C. M. Wetmore* (MIN), around mouth of Sevenmile Creek at Twelvemile Beach, along stream with *Thuja*, balsam fir, white birch and maple, 14.7.1987, *C. M. Wetmore* (MIN, UPS), an Sable Point, in edge of swamp behind point with balsam fir, *Thuja*, some white birch and hemlock, 13.7.1987, *C. M. Wetmore* (MIN,); Cheboygan Co., *Thuja* trunk in cedar swamp W of Hebrom Mail Road, 28.6.1974, *R. C. Harris* (NY), in oriente a Carp Creek prope University of Michigan Biological Station, ad corticem *Thujae occidentalis* in silva uliginosa, 21.7.1974, *R. C. Harris* (S, W; Vezda, *Lich. Selec. exs.* 1499), just N of Cheboygan Levering Road, just W of its intersection with Interestate 75, *Thuja* swamp, 21.8.1977, *J. Hafellner* (HAFELLNER), N. of Burt Lake, Reece's Bog, in *Thuja* swamp with *Betula* and *Picea glauca*, on bark of *Thuja occidentalis*, 19.8.1977, *L. Tibell* (UPS); Keweenaw Co., Isle Royale National Park, bog behind Spruce Point in Siskiwit Bay, *Thuja* bog with area in Center of black spruce, 22.7.1983, *C. M. Wetmore* (MIN, NY), Point Hay in Siskiwit Bay, mixed forest on point with balsam fir, birch, aspen and *Thuja* along shore, on conifer snag, 22.7.1983, *C. M. Wetmore* (MIN), south slope of ridge below new Feldtman lookout tower, upper slopes with rock openings and low areas with aspen and ash, 19.7.1983, *C. M. Wetmore* (MIN), Brady Cove off McCargo Cove, on N side in mixed forest near shore and swamp, 13.7.1983, *C. M. Wetmore* (UPS), 1,5 Km WNW of Windigo Inn., on trunk of old *Thuja occidentalis* in a swamp, 3.8.1972, *L. Tibell* (UPS); Lake Co. Cool Creek south of U.S. Forest Road 5202 west of Irons, *Thuja* swamp, 16.9.1968, *R. C. Harris* (MIN); Oscoda Co., *Thuja*, spruce swamp along East Branch of Big Creek upstream from Mapes Rd. (Co. 487), on *Thuja*, 14.9.1973, *R. C. Harris* (MIN); Presque Isle Co., trunk of *Thuja* in Cedar swamp at Evergreen Beach, 16.7.1974, *W. R. Buck* (NY); **Minnesota:** Beltrami Co., Red Lake Peatlands (27 miles south of

Bandette) west of highway 72, in bog in tamarack island with older trees, 31.8.1978, *C. M. Wetmore* (MIN); Cass Co., Otter tail Point on north side of Leech Lake (11 miles NE of Walker), in cedar swamp with *Thuja*, blasam fir and some basswood, 24.7.1976, *C. M. Wetmore* (MIN, UPS); Clearwater Co., Itasca State Park, at biology station in mixed upland woods at edge of swamp, on base of pine and on stump, 23.7.1974, *C. M. Wetmore* (MIN), near Peace Pipe Vista, in old red pine forest with scattered bogs, 30.7.1976, *C. M. Wetmore* (NY); Cook Co., Susie Islands near Grand Portage, on southwest island-point of Susie Island, along mossy rock ledges in black spruce and balsam fir woods, on white birch smag, 6.9.1980, *C. M. Wetmore* (MIN), Boundary Waters Canoe area, W shore of Whale Lake and the SE base of Eagle Mountain, 14 miles NW of Grand Marais, *Thuja*, white birch and balsam fir near the lakeshore, 2000 ft, 20.9.1986, *T. D. Trana* (MIN); Hubbard Co., Lasalle Creek just outside of NE corner of Itasca State Park, in spruce tamarack swamp, 4.8.1974, *C. M. Wetmore* (MIN, UPS); Itasca Co., Chippewa National Forest, in black spruce bog in experimental forest 20 miles N of Grand Rapids, 8.9.1980, *C. M. Wetmore* (MIN); Koochiching Co., Red Lake Peatlands (29 miles SSE of Bandette) east of highway 72, in bog in island of white birch, black ash and alder, 31.8.1978, *C. M. Wetmore* (MIN), Voyageurs National Park, in bay N of Graves Isl., in Black Bay, in ash bog on N side of bay with mostly young to middle age ash with some *Thuja* and balsam fir, 16.6.1979, *C. M. Wetmore* (UPS), Tom Cod Bay, swamp at western end of Kabetogama Lake, on north branch of river in *Thuja* swamp, on black spruce snag, 16.6.1978, *C. M. Wetmore* (MIN, BRA), near a bay on NE side of Black Bay ridge near bay with balsam fir, quaking aspen and some basswood and jack pines, on dead balsam fir, 14.6.1979, *C. M. Wetmore* (NY), at end of bay S of Big American Isl., in western Rainy Lake, along boggy stream with ash and some *Thuja* and balsam poplar, 15.6.1979, *C. M. Wetmore* (GZU); Lake Co., Crosby State Park, half mile N of entrance road along Blesner Creed (5 miles N of Little Marais), in *Thuja* woods near stream, 12.8.1980, *C. M. Wetmore* (MIN), Boundary Waters Canoe Area, E of Boy Scout Camp on E shore of Moose Lake, 19 miles ENE of Ely, *Thuja*-black ash swamp in valley between high N and S-facing cliffs, 1400 ft, 14.9.1986, *C. M. Wetmore* (MIN); St Louis Co., Boundary Waters Canoe Area, W of Little Indian Sioux River, 0,5 mile N of USFS Route 116, 24 miles NW of Ely, dry black ash-balsam fir and balsam poplar around the upland periphery, 1300 ft, 6.9.1986, *T. D. Trana* (MIN), Voyageurs National Park, Namakan Island in Namakan Lake, in low area in eastern part of island with black ash, *Thuja* and alder, on balsam fir snag, 21.6.1978, *C. M. Wetmore* (MIN), Sullivan Bay off eastern end of Kabetogama Lake, on steep rock hillside on south side of bay with black spruce and red pine and few white pine and balsam fir, 10.6.1978, *C. M. Wetmore* (UPS, SEAWARD), along Johnson River in Junction Bay on Namaken Lake, on east bank of beaver pond and falls in old *Thuja* stand with patches of ash, 28.6.1978, *C. M. Wetmore* (NY), two miles E of Anderson Bay on Rainy Lake, in small bay with mixed Conifer-hardwood forest up from bay with low rock cliffs above, 1.7.1979, *C. M. Wetmore* (GZU, S), on peninsula S of Namakan Narrows in Sand Point Lake, in mixed hardwood forest with scattered old spruce and some young balsam fir, 9.7.1979, *C. M. Wetmore* (MIN); Bemidji, on old tamarack branches, 7.7.1900, *B. Fink* (MIN, S); Emo, on Cedar, 19.7.1901, *B. Fink* (MIN, S); Bendetto, on cedar, 22.6.1901, *B. Fink* (MIN); Henning, on dead tamarack in swamp, 25.6.1900, *B. Fink* (MIN, S); **New Hampshire:** Mt. Washington, 9.1848, *E. Tuckerman* (BG, BRA, FH, MIN, US; Reliquiae Tuckermanianae 17); **New York:** Hamilton Co., along Brown Track Road near Raquette Lake Village, *Thuja*-spruce swamp, 7.9.1986, *R. C. Harris* (NY), Long Point, Raquette Lake, upland hardwoods, on yellow birch, 6.9.1986, *R. C. Harris* (NY, APTROOT); Jefferson Co., Wellesley Island State Park, thousand Islands, granite cliffs and hardwoods (S of campground E), on *Tilia*, 20.9.1983, *R. C. Harris* (NY, B); St. Lawrence Co., Cranberry Lake Campground, Bear Mountain Trail, beech-maple-yellow birch, 1500-1600 ft., 22.9.1983, *R. C. Harris* (MIN), wet northern hardwoods conifers along Oswegatchie River just E of Wanakena Ranger School, W of Cramberry Lake, 27.8.1988, *R. C. Harris* (MIN); Lake shore, near Buffalo, 1875, *Wilson* (FH); **Vermonth:** Essex Co., Adirondack Park, N shore of Lake Harris, 2 miles NNW of Newcomb, *Thuja-Betula* forest with scattered hardwoods and conifers, 14.9.1982, *T. D. Trana* (B); **Virginia:** Near St Martinsville, on bark of *Gleditschia*, 26.12.1893, *A. B. Langlois* (NY); **Wisconsin:** Ashland Co., Apostle Isl. Nat. Lakeshore, Rocky Island, inland from dock area on main ridge, in mixed forest of maples, *Thuja*, balsam fir and birch, 9.9.1987, *C. M. Wetmore* (MIN, NY), Devils Island, on high land near southern middle of island east of road, in mixed forest with big old white pines, birch and yew, 10.9.1987, *C. M. Wetmore* (MIN).

2. Cresponea flava (Vain.) Egea & Torrente (Figure 3)

Lecanactis flava Vain., Cat. Welwitsch. Afric. Plants 2: 430 (1901). **Type:** (Angola) Loanda, prope Boa Vista et Maianga do Povo, ad ramulos fruticum *Balsamodendron*, in collinis aridis maritimis, 2.1854, *C. Welwitsch* 186 (TUR-VAIN 26516, lectotype selected here).

Lecidea premnea Ach. var. *melargyra* Nyl., Flora 50: 5 (1867). **Type:** India, Calcutta, 1866, *S. Kurz* (H-NYL 10788, lectotype selected here; NY, S, UPS isolectotypes).

Thallus yellowish to greenish, seldon whitish, continuous, thin, effuse, sometimes delimited by a dark brown hypothalline line.

Ascomata sessile, roundish, constricted at base, scattered, 0,2-0,6 mm in diameter, with a smooth or dentate margin. Disc plane or slightly convexe, yellow-pruinose, become epruinose at maturity. Hymenium 70-85 µm, I+ blue or reddish. Subhymenium hyaline to pale brown, 20-25 µm, I+ blue or reddish. Paraphysoids up to 2 µm wide in the hymenium; apical cells tickened (3-4 µm), with a distinct dark brown cap wich is formed in the outer part of the cell

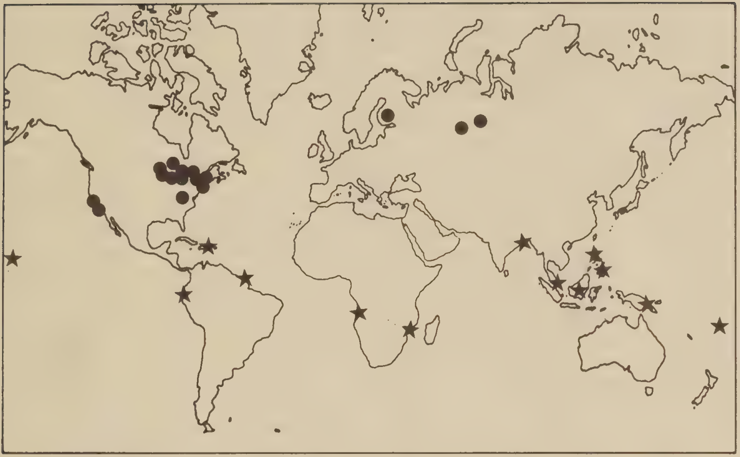

Figure 3. Distribution of: *Cresponea chloroconia* (●) and *C. flava* (★).

wall. Asci 45-55 x 13-17 µm. Ascospores oblong-fusiform to fusiform, 15-22(-24) x (4-)4,5-5,5 µm, 3 to 3-4(-5) septate, cell walls often thickened at septa.

Pycnidia immersed or subimmersed in the thallus, 140-160 µm tall, 110-130 µm wide. Conidia 3-5 x 1,2-1,5 µm, straight.

Distribution and habitat: *Cresponea flava* has a disjunct distribution in the Tropics. In the Neotropics it has a northern range comprising Ecuador, French Guiana and Hawaii. In the Paleotropics it is mainly an Indo-Malesian element, extending to Philippines in the north, and to Papua New Guinea, Angola and Mozambique, in the south. Altitude records range from sea level to 500 m, along the coastal hills, in mangroves or lowland moist forest. On tree of *Rhizophora sp.*, *Cocos nucifera*, *Eugenia peninsula*, *Adansonia sp.*, *Balsamodendron sp.*, in open or close forest.

Note: The type material of *Cresponea flava* has 3 septate ascospores. In the type material of *L. premnea* var. *melargyra* the ascospores are 3(-4-5) septate, and in other specimens (Hawaii, Papua New Guinea) the spores are 3-4(-5). In our opinion, these differences are not significant to distinguish two or more taxa. See under *Cresponea chloroconia* for comparison with that species.

Additional specimens examined: **BORNEO:** Labuan, 5°23' lat. bor., 115°12'long. occid., 11.1879, *E. Almquist* (S).- **DOMINICAN REPUBLIC:** San Pedro de Macoris, W shore of Rio Cumayasa, ca. 1 km S of hwy between San Pedro de Macoris
]

and La Romana, sea level, dry scrub over rough limestone, 18°26'N, 69°06'W, 19.1.1987, *R. Buck* (NY).- **ECUADOR:** Esmeraldas, La Tola, coastal area on bark, 5 m, 13.7.1982, *A. Aptroot & R. Hensen* (APTROOT).- **FRENCH GUIANA:** Saül, 2 km SW of the village, "sentier limonade", lowland moist forest on lateritic soil, epiphytic on lower trunk, 180-210 m, 10.2.1986, *D. Montfoort & R. C. Ek* (U).- **HAWAII:** Oahu Island, Keaiwa Heian state recr. area near Aiea, on tree in open forest, 500 m, 6.1989, *A. Aptroot* (APTROOT).- **MOZAMBIQUE:** *Carreira* (H).- **PAPUA NEW GUINEA:** Madang, Karkar island, NW side, in gardens near the Karkar District School, 10 m, on *Cocos* tree, 2.1987, *A. Aptroot* (APTROOT); National Capital District, Napa-Napa Road, 9 km NW of Port Moresby, sea level, on *Rhizophora* trunk, 15.2.1981, *H. Streimann & E. K. Naoni* (B, CBG, H).- **PHILIPPINES:** Luzon: island, Laguna, 60 km SE of Manila, Los Baños, College, University Campus, 50 m on tree, 2.1987, *A. Aptroot* (APTROOT), Sorsogon, Irosin, on the limbs of *Eugenia peninsula*, 1000 ft, 5.1916, *A. D. E. Elmer* (B); Mindanao, Umgebung von Davao, ca. 2 m, on *Cocos nucifera*, 4.11.1977, *G. Zehetleitner* (HAFELLNER).- **SAMOA:** Insel Upulu, in mangrove auf *Rhizophora mucronata*, 6.1905, *Rechinger* (W).- **SINGAPORE:** Fort Canning Park in the city, on tree in park, 50 m, 6.1984, *A. Aptroot* (APTROOT); Kusu Island off the coast on tree along the coast, 2 m, 6.1989, *A. Aptroot* (APTROOT); St. John's island off the coast on tree along the shore, 2 m, 6.1989, *A. Aptroot* (APTROOT); Singapore Botanical Garden, on *Cedrela toana*, 5.10.1983, *L. Tibell* (UPS).

3. Cresponea flavescens (Vain.) Egea & Torrente comb. nov.

(Figures 1G, 4)

Lecanactis flavescens Vain., Bol. Soc. Brot., ser. 2, 6: 148 (1929-30). **Type:** Mozambique, prope Palma, ad corticem arboris, 1916, *A. Pires de Palma* (TUR-VAIN 33786, lectotype selected here).

Thallus whitish, continuous, thin, with smooth to uneven surface, effuse, delimited by a thin, black, marginal hypothalline line.

Ascomata scattered, roundish, with constricted base, 0,4-1 mm in diameter; margin prominent, somewhat dentate or crenulate. Disc plane or slightly convex, yellow-reddish pruinose. Hymenium hyaline, 95-115 µm, I+ blue/reddish. Subhymenium hyaline 15-50 µm, I+ blue. Paraphysoids up to 2 µm wide in the hymenium; apical cells thickened (3-5 µm), with a distinct +/_ dark brown cap wich is formed in the outer part of the cell wall. Asci 60-70 x 15-16 µm. Ascospores fusiform, 20-26(-28) x (4,5-)5-6 µm, 5-7(-9) septate, cell walls thickened at septa and locules roundish to sublentiform.

Pycnidia not found.

Distribution and habitat: Cresponea flavescens is known only from the type locality in Mozambique.

4. Cresponea follmannii (Dodge) Egea & Torrente (Figure 4)

Lecanactis follmannii Dodge, Nova Hedwigia 12: 327 (1966). **Type:** Chile, Aconcagua Province, Quebrada del Tigre, 500 m, on weathered dead wood, 300 m, *G. Follmann* 14624 (FH, holotype).

Thallus white, very thin, effuse poorly developed, to inexistent.

Ascomata numerous, sessile, scattered or seldon crowded, roundish, constricted at base, 0,1-0,6 mm in diameter, with smooth or dentate margin. Disc concave or plane, greyish pruinose when young, soon becoming epruinose. Hymenium 60-70 µm, I+ reddish. Subhymenium hyaline in the outer part, brown in the inner part, 25-35 µm I+ reddish. Paraphysoids up to 1,5 µm wide in the hymenium; apical cells thickened (4-5 µm), with a distinct dark brown cap wich is formed in the outer part of the cell wall. Asci 48-60 x 10-12 µm. Ascospores fusiform, straight or often curved and more or less reniform, 15-20(-22) x 4-4,5 µm, 3(-4) septate; cell walls not or few thickened at septa.

Pycnidia not found.

Distribution and habitat: Cresponea follmanii is known only from the type locality in Chile.

Notes: In the protologe of *Cresponea follmanii* (Dodge 1966) the ascospores are 5 septate. In the holotype investigated we found the ascospores only 3(-4) septate. See under *C. chloroconia* for comparison with that species.

5. Cresponea leprieurii (Mont.) Egea & Torrente comb. nov. (Figures 2E-G, 4)

Lecidea leprieurii Mont., Ann. Scic. Nat. Bot., sér. 3, 16: 56 (1856).- *Lecanactis leprieurii* (Mont.) Tuck., Proc. Amer. Acad. Arts 6: 285 (1864). **Type:** Guyana, ad cortices, *Leprieur* 763 (not found).

Lecidea insignior Nyl., Acta Soc. Sci. Fenn. 7: 463 (1863).- *Lecanactis insignior* (Nyl.) Vain., Etud. Lich. Brésil 2: 91 (1890). **Type:** Nova Granata (Colombia), Villeta, 2200 m, *Lindig* 2688 (H-NYL 10809, lectotype here selected; FH, H-NYL 5422 p.m., W, isolectotypes).

Opegrapha insignior (Nyl.) Müll. Arg. var. *fusca* Müll. Arg., Flora 69: 311 (1886).- *Lecanactis insignior* var. *fusca* (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 2: 538 (1924). **Type:** Brésil, Minas Geraes, *Glaziou* (G, lectotype here selected; FH, H, S, UPS, W, isolectotypes).

Lecanactis americana Vain., Etud. Lich. Brésil, 2: 92 (1890). **Type:** Brésil, Rio de Janeiro, 1885, *A. Vainio* (TUR-VAIN 26486, lectotype here selected; Vainio, *Lich. Brasilienses exs.* 174, isolectotype).

Lecanactis lividula Vain., Dansk Bot. Ark. 4(11): 24 (1926). **Type:** Mexico, Mirador, ad corticem ramulorum arboris, 8.1841, Liebm. Pl. Mex. 760 (TUR-VAIN 33788, lectotype here selected; TURN-VAIN 33787 isolectotype).

Thallus whitish, greyish or greenish, continuous, cracked, thin, hypothalline line inapparent.

Ascomata scattered or crowded, roundish or slightly contorted through mutual pressure, sessile, constricted at base, 0,5-2,5 mm in diameter, occasionaly with a central column of steril tissue, with a prominent, smooth or often crenulate margin. Disc plane or slightly convex, yellowish to reddish brown pruinose, becomes epruinose at maturity. Hymenium 100-160 µm, I+ blue or reddish. Subhymenium hyaline to pale brown, 30-65 µm, I+ blue. Paraphysoids up to 2 µm wide in the hymenium; apical cells thickened (3-5 µm), with a distinct red to dark brown cap which is formed in the outer part of the cell wall. Asci 82-95 x 16-27 µm. Ascospores fusiform to narrowly fusiform, (34-)38-65 x 5-7 µm, (8-)9-14 septate; cell wall not or little thickened at septa.

Conidia 3-5 x 1 µm.

Distribution and habitat: *Cresponea leprieurii* is found in the Caribbean islands, Guayana Highlands, Amazonian and Brazilian regions. Two localities remain isolated in USA (Washington) and Australia (Queensland). It occurs in mangroves, rainforest and tall montane forest, between sea level and 2000 m. It has been recorded from the following phorophytes: *Jacaranda* (?), *Gymnanthes* and *Podocarpus*.

Notes: In the protologue to *Cresponea leprieurii* (Montagne 1851) and *Lecanactis americana* (Vainio 1890), the authors states that the ascospores are up to 80 µm long. However, in a close examination of the holotype of the latter species and all related specimens examined we found no spores longer than 65 µm. Specimens with reddish pruina were previously named as *"Lecanactis" leprieurii*, specimens with green to yellowish pruina were named as *"Lecanactis" insignior*, whereas epruinose specimens were named as *"L." insignior* f. *fusca*. Specimens from Mexico, including the type material of *"Lecanactis" lividula* and from USA are assigned to this species although they differ slightly in having shorter ascospores.

Additional specimens examined: **ARGENTINA:** *Lopez & Hieronymus* (W).- **AUSTRALIA:** Queensland: Bunya Mountains National Park, about 56 km NE of Dalby, Koondaii Lookout Track W of Westcott Plain, ca. 100 m, rainforest, 2.9.1986, *G. N. Stevens* (GZU), Mt. Spec State Forest, Paluma Range, 6 km W of Paluma, 19°01'S, 146°09'E, on sapling in Lauraceae-*Syzygium* dominated forest, 920 m, 18.6.1986, *J. A. Elix & H. Streimann* (CBG), Tully Falls Road, 18 km SE of Ravenshoe, 17°46'S, 145°33'E, rainforest on flats, on roadside shrub, 760 m, 23,6,1984, *H. Streimann* (CBG).- **BRAZIL:** Matto Grosso, etwa 35 km südöstlich von Cuiaba, in einem ziemlich dunklen Galeriewald am Fluss Arica-Açu, 120 m, 4.7.1980, *K. Kalb* (GZU), Serra da Guia fir Cuyabá, 12.5.1894, *G. A. Malme* (FH, S), Bandaira fir Cuyabá, 14-5-1894, *G. A. Malme* (S, UPS), Corumbá, in cortice *Jacaranda*, in dumeto claro pr. oppidum, 10.8.1894, *G. A. Malme* (G, S, UPS), Ribeirao Machade fir Cuyabá, 14.5.1894, *G. A. Malme* (S); Miñas

Geraes, Monte Verde, E of road Sao Paulo-Belo Horizonte, ca. 10 m, tall montane forest on slope towards Pedra Redonda, 1750 m, 3.7.1979, *H. Sipman* (B), near camping site E of the Monte Verde, 1600 m, tall, light, montane forest with *Araucaria* and *Podocarpus* in valley, on *Podocarpus*, 2.7.1979, *H. Sipman* (B), Serra do Espinhaço, Serra do Caraça, Nordwesthang des Berges Carapuça, bei den Groutas do P. Trombert, an einem Laubbanm, in einem feuchtem, dunklen, ursprünglichen Regenwald, 1350 m, 12.7.1978, *K. Kalb & G. Plöbst* (GZU); Rio Grande do Sul: Hamburgerberg fir Sao Leopoldo, 21.10.1892, *G. A. Malme* (UPS), Santo Angelo fir Cachoeira, 28.1.1893, *G. A. Malme* (S, UPS), Serra das Vallas, fir Cruz Alta, in silva clara *Araucaria*, 21.4.1893, *G. A. Malme* (S, UPS); Rio de Janeiro: Serra da Itatiaia, along road Gargantua de Registro Agulhas Negras, 1650 m, on treetrunk in ca. 15 m tall forest, 10.7.1979, *H. Sipman* (B); Sao Paulo: near Cananeia, on the atlantic coast S of Sao Paulo, Ilha Comprida, near road to Cananeia ferry, 0 m, open, ca. 3 m tall shrub vegetation with dense undergrowth of Bromeliaceae, close to the beach, 16.7.1970, *H. Sipman* (APTROOT).- **COLOMBIA** (Novo-Granatensis): Lamesa, 2400 m, 1860, *Linding* 2643 (FH, PC); Fusagasugá, 2100 m, 1861, *Linding* 2863 (PC).- **COSTA RICA:** San José, cordillera de Talamanca, ca. 5 km W of Cerro de la Muerte, San Gerardo de Dota, along Quebrada Ojo de Agua, epiphytes, 2800 m, 21.3.1985, *H. Sipman & A. Chaverri* (B).- **CUBA:** Isle of Pines, Cerro San Juan del Mar, Columbia, on *Gymnanthes*, 20.2.1916, *N. L. Britton, E. G. Britton & P. Wilson* (FH, NY); Oriente, Noguera's Hill, 27.10.1921, *B. Hioram* (NY); Prov. Santiago de Cuba, La Gran Piedra, SE of peakin humid, secondary forest, ca. 1000 m, 2.4.1982, *R. C. Harris* (NY); Wright (FH).- **FRENCH GUIANA:** Saül, 2 km SW of the village, "sentier limonade", 180-210 m, lowland moist forest on lateritic soil, epiphytic in lower canopy of *Virola melinonii*, 22.7.1986, *D. Montfoort & R. C. Ek* (U).- **JAMAICA:** 1912, *J. H. Hart* (NY).- **MEXICO:** Jalisco, La Huerta, ca. 125 km NW of Manzanilo, Chamela Biological station (UNAM), tropical deciduous forest, on bark of trunk of living tree, in very shaded gully, 18.3.1985, *J. Grimes* (NY); Nuevo Leon, Monterey, Sierra de la Silla, 2.6.1889, *C. G. Pringle* (FH); San Luis Potosí, Las Palmas, 6.6.1890, *C. G. Pringle* (FH, NY).- **PUERTO RICO:** Distr. Ponce, Cordillera Central, above Villalba, Doña Juana Recreation Area, 800-1000 m, wet broadleaf-palm forest on leeward slope, 2.6.1988 (NY).- **USA:** **Washington:** W. W. Calkin's, North American lichens 113 (NY).- **PARAGUAY:** Colonia Risso, in silva satis clara, 23.8.1843, *G. A. Malme* (FH, S, UPS); fir Concepcion, 17.9.1893, *G. A. Malme* (S); Gran Chaco, ad Pilcomayo, 4.9.1893, *G. A. Malme* (S).

6. Cresponea leprieuroides (Nyl.) Egea & Torrente

(Figure 4)

Lecidea leprieuroides Nyl., J. Lich. Soc. London Bot., 20: 56 (1883).- *Lecanactis leprieuroides* (Nyl.) Zahlbr., Cat. Lich. Univ. 2: 539 (1924). **Type:** Malacca, Allagajah, 1864, *Maingay* (H-NYL 10858 lectotype here selected; FH, isolectotype).

Thallus whitish, well developped, with uneven surface, granulose, often lepraroid; hypothalline line inapparent. In section up to 700 µm high.

Ascomata scattered, adnate to sessile, 0,3-1,5 mm in diameter, with smooth or somewhat dentate margin. Disc plane to slightly convex, dark red pruinose, becoming epruinose. Hymenium 100-120 µm, I+ blue. Subhymenium pale brown, 50-60 µm, I+ blue. Paraphysoids up to 1,5 µm wide, in the hymenium; apical cells thickened (3-4 µm), with a distinct red to dark brown cap wich is formed in the outer part of the cell wall. Asci 75-90 x 15-18 µm. Ascospores fusiform, 25-30(-34) x 5-7 µm, 6-7 septate, cell walls +/_ thickened at septa; lumina roundish to sublentiform.

Pycnidia not found.

Chemistry: Thallus K-, C+ reddish, KC-, P-. Lecanoric acid.

Distribution and habitat: Only known from Malacca.

Notes: This taxon is easily identified by its lepraroid, C+ reddish thallus.

Additional specimen examined: **MALACCA:** On *Pterocarpus indicus*, 1864, *Maingay* (H-NYL 10860); Tanjong, 4.1866, *Maingay* (FH).

7. Cresponea macrocarpoides (Zahlbr.) Egea & Torrente comb. nov.

(Figures 2K-L, 4)

Lecanactis macrocarpoides Zahlbr., Feddes, Repert. 31: 224 (1933). **Type:** Formosa (Taiwan), Toroyen, Mt. Arisan, 24.12.1925, *Y. Asahina* 169 (W, lectotype).

Thallus whitish, continuous, thin, effuse, poorly developed, mostly endophloeodes; hypothalline line inapparent.

Ascomata scattered, sessile, roundish, constricted at base, 0,2-1 mm in diameter, with +/_ undulating smooth margin. Disc plane or slightly convex, ochraceous pruinose when young, soon becoming epruinose. Hymenium 90-110 µm, I+ reddish. Subhymenium pale brown, 25-40 µm, I+ reddish. Paraphysoids up to 2 µm wide, in the hymenium; apical cells thickened (3-4 µm), with a distinct dark brown cap wich is formed in the outer part of the cell wall. Asci 70-80 x 15-18 µm. Ascospores narrowly fusiform, 40-55(-65) x 3,5-5 µm, 7-10(-11) septate; cell walls not thickened at septa.

Pycnidia not found.

Distribution and habitat: Only known from the type locality in Taiwan.

Notes: *C. macrocarpoides* is similar in many respects to *C. leprieurii*, which is distinguished by the narrower spores and smaller ascomata.

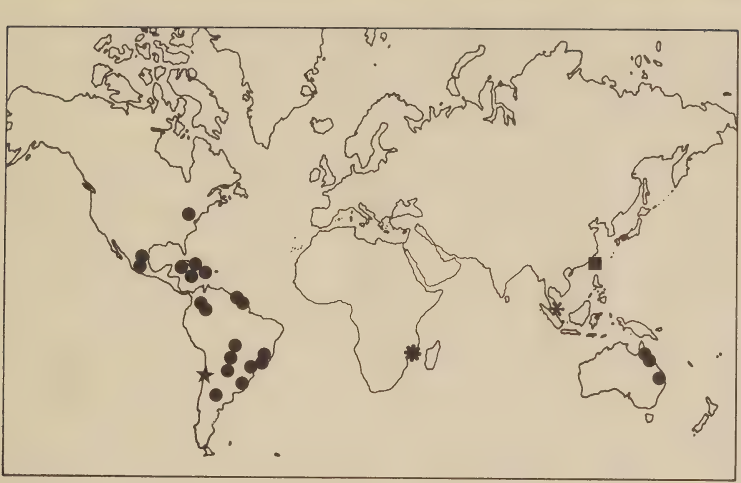

Figure 4. Distribution of: *Cresponea flavescens* (❋), *C. follmannii* (★), *C. leprieurii* (●), C. *leprieuroides* (✳) and *C. macrocarpoides* (■).

8. Cresponea melanocheloides (Vain.) Egea & Torrente comb. nov. (Figures 2H-J, 5)

Lecanactis melanocheloides Vain., Mycologia 21: 37 (1929). **Type**: Porto Rico, Mameyes, on bark in woods, 10.12. 1915, *B. Fink* 768 (TUR-VAIN 33789, lectotype here selected; FH, H, NY, isolectotypes).

Thallus pale green, continuous, cracked, thin, with smooth to uneven surface, effuse; sometimes with a thin, black, marginal hypothalline line.

Ascomata scattered, sessile, roundish, constricted at base, 0,5-1,5 mm in diameter, with prominent, crenulate margin. Disc plane or slightly convex, green-yellowish to reddish pruinose. Hymenium 120-150 µm, I+ reddish. Subhymenium pale brown, 30-50 µm, I+ reddish. Paraphysoids up to 2 µm wide, in the hymenium; apical cells thickened (3-5 µm), with a distinct red to dark brown cap wich is formed in the outer part of the cell wall. Asci 80-105 x 17-22 µm. Ascospores fusiform to narrowly fusiform, 63-90 x (5,5)6-7 µm, 13-19 septate; cell walls +/_ thickened at septa and lumina roundish to rectangular.

Pycnidia not found.

Distribution and habitat: *C. melanocheloides* is a Neotropical element, at present known from the Caribbean islands, Brazil and French Guiana. On tree in moist to dry forest.

Notes: In the protologe of *C. melanocheloides* (Vainio 1929) the ascospores are said to meassure 46-66 x 5-7 µm. In the types investigated we found longer ascospores, 63-85 x 5,5-7 µm. The longest ascospores in *Cresponea* are found in specimens of this species.

Additional specimens examined: **BRAZIL:** Bahia, Mun. Tremedal, km 72 on BA 262 between Vitoria da Conquista and Brumado, 21,5 km WNW of Anajé, 29 km SE of Aracatu, ca. 650 m, ca. 14°32', 41°05'W, caatinga vegetation, 19.7.1991, *D. M. Vital & W. R. Buck* (NY).- **CUBA:** Oriente, Bayate, 12. 1923, *B. Hioram* (NY).- **DOMINICAN REPUBLIC:** La Altagracia: Lomo El Peñón de la Vieja Rufina, 24 km SE of Otra Banda on road to Punta Cana, mesic forest on limestone ridge, 29.3.1981, *W. R. Buck* (NY), Parque Nacional del Este, along trail from park entrance to sea, 18°21'N, 68°37'W, dry forest, 30.3.1981, *W. R. Buck* (NY); Prov. Puerto Plata, 4,5 km S of Sosúa-Puerto Plata Hwy at Sosúa just W of Rio Sosúa, near source of Rio Sosúa, 19°41'N, 70°31'W, moist primary forest near sea level, 24.1.1991, *R. C. Harris* (NY).- **FRENCH GUIANA:** Saül, 2 km SW of the village, "sentier limonade", 180-200 m, lowland moist forest on lateritic soil, on tree base of *Ceiba pentandra*, 3.9.1986, *D. Montfoort & R. C. Ek* (U).- **HAYTI:** Bayeux, 12.8.1903, *V. Nash* (NY).- **TRINIDAD:** Southern Watershed Reserve, on live tree, 28.3.1920, *E. G. Britton, D. Coker & W. R. Rowland* (NY).

9. Cresponea plurilocularis (Nyl.) Egea & Torrente comb. nov. (Figures 2D, 5)

Lecidea premnea var. *plurilocularis* Nyl., Ann. Sci. Nat. Bot., sér. 4, 15: 49 (1861).- *Lecidea plurilocularis* (Nyl.) Nyl., Acta Soc. Sci. Fenn. 7: 463 (1863).- *Lecanactis plurilocularis* (Nyl.) Zahlbr., Akad. Wiss. Wien, Math.-Naturwiss. Kl., Denkschr. 81: 244 (1907).- *Lecanactis quassiae* (Fée) Zahlbr. var. *plurilocularis* (Nyl.) Zahlbr., Cat. Lich. Univ. 2 : 545 (1924). **Type:** Nova Caledonia, ad corticen *Baloghiae drupaceae*, *D. Pancher* (H-NYL 10823, lectotype here selected).

Opegrapha plurilocularis (Nyl.) Müll. Arg. var. *obfuscata* Müll. Arg., Flora 65: 505 (1882).- *Lecanactis quassiae* var. *obfuscata* (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 2: 545 (1924). **Type:** Australia, Queensland, Toowoomba, *Hartmann* 35 (G, lectotype here selected).

Bombyliospora neocaledonica Räs., Ann. Bot. Soc. Zool.-Bot. Fenn. "Vanamo" 20(3): 27 (1944). **Type:** Nova Caledonia, Noumea, ad cort. arb., *F. R. M. Wilson* (H, lectotype here selected).

Thallus whitish to greenish, continuous, cracked or rarely areolate, often delimited by a thin dark brown hypothalline line. In section up to 450 µm.

Ascomata scattered, sessile, constricted at base, 0,2-1,8 mm in diameter, sometimes with a central column of steril tissue, with a smooth or crenulate margin. Disc plane or slightly convex, green-yellowish to ochraceous-yellowish pruinose when young, becomes +/_ epruinose at maturity. Hymenium 80-110 µm, I+ reddish. Subhymenium hyaline or pale brown, 25-50 µm, I+ blue or reddish. Paraphysoids up to 2 µm wide, in the hymenium; apical cell thickened (4-5 µm), with a distinct +/_ dark brown cap wich is formed in the outer part of the cell wall. Asci 65-100 x 18-22 µm. Ascospores fusiform 30-43(-45) x 6-8(-9) µm, 7-10(-11) septate, cell walls +/_ thickened at septa, and lumina roundish to sublentiform.

Pycnidia immersed or subimmersed in the thallus. Conidia 4-6 x 1-1,2 µm.

Distribution and habitat: *Cresponea plurilocularis* is an Australasian element extending northward to reaching the Malesian region. Corticolous, on tree or scrub trunks in tropical or subtropical rainforest, to dry, subtropical scrub forest, at present, collected between 300-1000 msm.

Notes: *Cresponea plurilocularis* has been regarded as a variety of *Lecanactis quassiae* (Fée) Zahlbr. (Weber & Wetmore 1972, Awasthi 1991). In our opinion, *L. quassiae* is a "nomen dubium", because the type material is apparently lost (not found in any of the presumible herbaria), the diagnosis is rather imprecise and the locality unsure "habitat in Jamaica ? ad corticen Quassiae excelsa". At present, specimens related with *Cresponea plurilocularis* have not been found in Jamaica. Other probably older name for *C. plurilocularis* is *"Lecidea" coniochlora* Mont. et v. de Bosch, described from Java (Montagne 1856). As in *Lecanactis quassiae*, the protologe is imprecise, and the type material has not been found.

Additional specimens examined: **AUSTRALIA:** New South Wales: Blue Mountains, 4 km SE of Blackheath, walking track from Neates Glen via Grand Canyon to Evans Lookout, ca. 900-1000 m, 3.1.1985, *H. Mayrhofer* & *A. Archer* (GZU), Mount Wilson-Mount Irvine Road, 25 km NNE of Katoomba, 33°3'S, 150°23'E, 750 m, cool temperate forest (Cunoniaceae dominated) on slope, on treelet stem, 1.11.1984, *H. Streimann* (CBG); Queensland: Atherton Tableland, 18 km S of Atherton, Mt. Hypipamee, at Crater Lake, 17°25'S, 145°33'E, ca. 900 m, on bark in rainforest, 30.10.1983, *L. Tibell* (UPS); D'Aguilar Range NW of Brisbane, W of Mt. Glorious township, 680 m, edge of a rainforest, 1.8.1986, *J. Hafellner* & *R. Rogers* (GZU); Great Dividing Range, on the road to Bald Mtn. about 7 km NE of Mt. Colliery, E of Warwick, 1000 m, small pocket of remainign rainforest on the ridge, 7.9. 1987, *J. Hafellner* & *N. Stevens* (GZU); Hurdle Gully, 14 km WSW of Monto, 300 m, dry, semitropical scrub forest on creek flats, on tree trunk, 16.1.1980, *H. Streimann* (B, CBG, H); Lamington National Park, 100 km S of Brisbane, near lost World, 300 m, on tree in subtropical rainforest, 2.1988, *A. Aptroot* (APTROOT); Lamington National Park, Moran Falls, 28°02'S, 152°56'E, in wet sclerophyll forest, on trunk of tree, 28.4.1981, *L. Tibell* (UPS); 6 km N of Jimma, 26°35'S, 152°26'E, in transition zone between *Eucalyptus* forest and rainforest, on bark, 2.5.1981, *L. Tibell* (UPS); 45 km SW of Kingaroy, Bunya National Park, Westcott

Plain, 26°52'S, 151°47'E, ca. 1000 m, in S-facing slope, on bark, 13.11.1983, *L. Tibell* (UPS); 66 km W of Mackay, Eungella National Park, 21°11'S, 148°20'E, close to the campsite, along Broken River, Fringe of rainforest, on bark, 10.10.1983, *L. Tibell* (UPS); Mt. Mee State Forest N of Dayboro, W of Caboolture, 8.10.1981, *H. Mayrhofer & R. Rogers* (GZU); Mt. Mee State Forest, nort of Dayboro, Old, 500 m, bark of tree branch form the canopy, 9.6.1981, *R. Rogers* (UPS); Killarney, corticola, 1890, *F. R. M. Wilson* (H); Brisbane, 1889, *F. R. M. Wilson* (H); Super corticen arborum prope Toowoomba, *Hartmann* (S, W; Lojka, *Lich. Univ.* 141).- **BORNEO:** Lebuan, 5°23'lat.bor., 115° 12'long. occid., 17-21.11.1879, *E. Almquist* (H, S).- **INDONESIA: Java,** Batavia, ad arborum truncos in horto botanico Buitenzorgensi, ca. 260 m, 20.11.1893, *V. Schiffner* (FH); **Sumatra,** 16 km W of Bukittinggi, Lake Maninjan, tropical rainforest, 500 m, on tree, 4-1988, *A. Aptroot* (APTROOT).- **OCEANIA: Lord Hower Island:** corticola, 1892, *F. R. M. Wilson* (H); **New Caledonia:** Lifu, Layalty, 1864, *Chiébaut* (H); Balade, *Vieillard* (H); Mt. Atso, T. Savés (W).- **NEW ZEALAND:** North Island, Gisborne, Urewera National Park, at Lake Waikaremoana, 1,5 km SE of Lakehouse, along track to Ngamoko Trig, 38°46'S, 177°10'E, ca. 725-850 m, in mixed podocarp-hardwood forest, on trunk of *Nothofagus fusca*, 18.5.1981, *L. Tibell* (UPS); South Island, Southland, Longwood S.F., 19 km NNW of Riverton, along Pourakino River, N of Pourakino Campground, 46°11'S, 167°55'E, ca. 150 m, mature *Notofagus menziesii* forest, on trunk of old *N. menziesii*, close to the base, 16.1.1981, *L. Tibell* (UPS).

10. Cresponea premnea (Ach.) Egea & Torrente comb. nova var premnea

(Figures 1C-F, 2B, 5)

Lecidea premnea Ach., Lichenogr. Univ. 173 (1810).- *Lecanactis premnea* (Ach.) Arnold, Flora 44: 664 (1861). **Type:** Angliae (not seen).

Thallus whitish to greyish, continuous, cracked to areolate, smooth, thin, effuse, usually poorly developed, occasionaly delimited by a dark brown hypothalline line. In section up to 150 µm high.

Ascomata scattered, sessile, constricted at base, roundish to somewhat iregular, 0,3-0,8(-1) mm in diameter, with a smooth or more often crenulate margin. Disc plane, with a greenish or greyish pruina when young, epruinose at maturity. Hymenium 60-120 µm, I+ reddish, K/I+ blue. Subhymenium 25-40 µm, brownish in the inner part and hyaline in the upper part, I+ and K/I+ blue. Paraphysoids 1,5-2 µm wide in the hymenium; apical cell thickened (4-5 µm), with a distinct dark brown cap which is formed in the inner part of the cell wall. Asci 60-75(-80) x 12-13 µm, at maturity. Ascospores fusiform, 20-27(-30) x 4-5(-5,5) µm, 5-7 septate, straight or slightly curved, with cell wall widened at septa.

Pycnidia immersed or subimmersed in the thallus. Conidia 3-5 x 1-1,2 µm, straight.

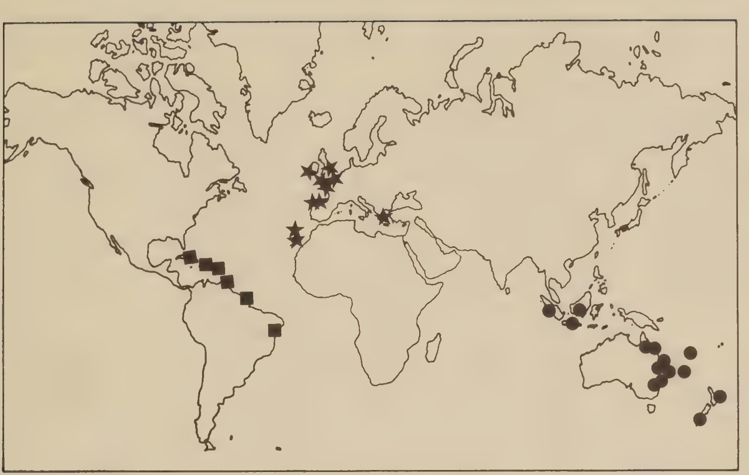

Figure 5. Distribution of: *Cresponea melanocheloides* (■), *C. plurilocularis* (●) and *C. premnea* var. *premnea*(★).

Distribution and habitat: *Cresponea premnea* occurs mainly in oceanic or suboceanic areas of the Eurosiberian region, in colline to submontane belt, southward extending to the north of the Mediterranean region, Madeira and, according with Gil-Gonzalez *et al.* (1990), Tenerife. It has been mentioned from USA (Tuckerman 1888, Fink 1935) and Japan (Nylander 1890), but these identifications need to be confirmed (see Notes). Corticolous, it is usually found in deciduous forest and on old, scattered, deciduous trees (*Quercus*, *Fagus*,...), in the *Lecanactidetum premneae* P. James et al., an association described from the south of the British Island (James et al. 1977)

Notes: *Cresponea premnea* differs from related species, as *C. flavescens*, mainly by the distinct inner dark brown cap of the apical cell of paraphysoids.

We have analyzed three specimens deposited in the FH herbarium from South Carolina and Louisiana (USA), labelled as *Lecanactis* (= *Cresponea*) *premnea*. However, the specimens differ from the latter species, in having ascospores (17-)19-23 x 4-5 µm, 3(-4-5) septate, not thickened at septa. On other hand, the ascospores are bigger and more septate than in *C. chloroconia*. The size and number of septa of the ascospores suggest close affinities with *C. flava*, which differs in having the apical cell of paraphysoids dark brown in the outer part, and the ascospores are widened at septa. *Lecanactis premnea* var. *tunisea* (Hue) Zahlbr., is *Lecanidion atratum* (Hedw ex Fr.) Rabenh., after examination of the type material (*Lecidea premnea* var. *tunisea* Hue in Patouill., Plant. Cellul. Tunisie 148: (1897). Type: Sur

Robinia à Tunis, 1.1893, *Patouillard* (PC, lectotype here selected).

Specimens examined: **FRANCE:** Bretagne, Chaos de Herbot, on *Quercus*, 28.7.78, *A. Aptroot* (APTROOT), Foret de Paimpont, Treassau, 16.7.1954, *E. Dahl* (O); Finistère, ca. 5 km SW of Huelgoat de St. Herbot, old deciduous forest in little valley of river Ellez, on thick trunk of old *Quercus* tree, 200 m, 22.7.1978, *H. Sipman* (U); Manche, an Mauerlehm der Häuser und Pachtgebäude in Canisy, 1891, *Hue* (S); Morbihan, Château de Trécesson en Campénéac, on the trunk of an old oak, 16.7.1954, *R. Santesson* (S, UPS); Normandie, an Baumrinden bei Vire, *Pelvet* (Bern, FH, S; Hepp, *Flecht. Europ.* 514).- **GREAT BRITAIN:** Co. Devon: W of Bideford, Clovelly, pastures with forests on N-exposed slope W of the village, on shady trunk of *Acer pseudoplatanus* tree, 100 m, 2.9.1971, *H. Sipman* (B), Clovelly, loofbos op noordhelling, op Esdoorn, 100 m, 71, *R. Pos* (U); Co. Somerset: Exmoor, S of Porlock, wooded valley N of Dunkery Hill, on *Fraxinus* trunk in deciduous forest on the botton of the Valley, ca. 500 m, 31.8.1971, *H. Sipman* (U, B), Exmoor, valley nord van Dunkery Hill, op *Fagus*, 500 m, 71, *R. Pos* (U); Broomfield, Som, V. C., old oak, 26.1.1913, *W. Watson* (FH); Cambridgeshire, Chevely Park (W); Cardiganshire, Wales, Strata Florida Abbey, on bark, (FH); Castlebernard Park, on oak (O, Carroll, *Lich. Hib.* 15); Cleveland, Kildale, on the trunks of trees (W, Mudd, *Lich. Brit. exs.* 197); New Forest, Denny Wood, on *Quercus*, 7.10.1988, *M. R. D. Seaward* (SEAWARD); Oxfordshire, Thame Park, old trees (W); Shropshire, on oak, haughmond and Grinshill Hills (O; Leight, *Lich. Brit.* 124); Slish Wood, on *Quercus*, 1.9.1987, *M. R. D. Seaward* (SEAWARD).- **GREECE:** Attika, Lichter *Abies cephalonica*-Wald auf dem Parnis, NO Athen, bei Ag. Trias, 11.4.1971, *J. Poelt* (GZU).- **IRELAND:** Kerry, south shore of Muckross lake, 10.9.1982, *P. M. Jorgensen* (BG); North Kerry, Eagle's Nest SW of Killarney, 14.8.1966, *P. W. James* (WIRTH).- **PORTUGAL:** Madeira, 1866 (H).- **SPAIN:** Canarias, Gomera, El Cedro, 800 m, laurisylva with rock outcrop, on *Laurus azorica*, 2.4.1983, *A. Aptroot* (APTROOT); La Coruña, Santiago de Compostela, Carballeira de San Lorenzo, 245 m, on *Quercus robur*, 7.5.1984, *R. Carballal* & *M. E. López de Silanes* (MUB); Pontevedra, Vigo, 14m, on Alnus glutinosa, 8.1984, M. E. López de Silanes (MUB).

var saxicola (Leight.) Egea & Torrente comb. nov (Figure 6)

Lecidea premnea var. *saxicola* Leight., Lich. Flora Great Brit. 3: 365 (1879).- *Lecanactis premnea* var. *saxicola* (Leight.) Oliv., Bull. Géogr. Bot. 21: 207 (1911). **Type:** (England), Airyholme Wood, Cleveland, Yorkshire, *W. Mudd*, Lich. Brit. Exs. 198 (BM, lectotype here selected; S, UPS, W, isolectotypes).

Lecanactis plocina auct.

As for *Cresponea premnea* var. *premnea* but with the following differences: Thallus poorly developed and granulose, bigger ascomata (up to 1,1 mm in diameter), wider asci (13-15 µm), and wider ascospores (5-6 µm).

Distribution and habitat: This taxon occurs in oceanic or suboceanic, temperate areas of the Eurosiberian region, from British Isles to Rumania in the colline to submontane belt; southward extending to Iberian Peninsula and Morocco. It is present in USA (Alabama and Missouri). It is mainly found in coastal or inland, saxicolous, shaded, ombrophobous communities.

Notes: The specimens of *Cresponea premnea* var. *saxicola* from USA are similar to the Europaean populations in all characters investigated .

Additional specimens examined: **FRANCE:** Ille-et-Vilaine: ad saxa lutosa in locis umbrosis prope Guichen, Ipse (BG, BRA; H. des Abbayes, *Lich. Armoric. spect. exs.* 117); Lot-et-Garonne: Fumel, Cuzorn, 1924, *A. F. Jeanjean* (S, STU); Manche: Murs d'argile à Dangy, 1889, *Hue* (S), ad Mahuerlehm der Hauser und Pachtgebäude in Canisy, 1891, *Hue* (O, W; Arnold, *Lich. Exs.* 1558); Vosges, Docelles, supra saxa arenaria (FH, W; Claudel & Harmand, *Lich. Gallici praecipui exs.* 93), Fontaineblau, ad saxa locis umbrosis (FH, W; Nylander, *Herb. lich. Paris* 67).- **CZECHOSLOWAKIA:** Böhmen, Sandsteinbrüche bei Skrovad (Kreis Chrudim, V. Kuták (BERN, S, W; Zahlbr., *Lich. Rariores Exs.* 301); Chrudim, prope pagum Skrovád in rupe arenaceae, ca. 280 m, *V. Kuták* (BCC, BRA, S, W, WIRTH; Suza, *Lich. Bohemosl.* 246; UPS; Kuták, *Lich. Bohemiae* 356).- **GERMANY:** Baden: an Sandsteinblöcken auf dem Bernsteine im Margthale, 8.1870, *Bausch* (FH, S; Rabenhorst, *Lich. Europ.* 895), Heidelberg, an Sandstein und Granïtfelsen, *W. Ahles* (FH, NY, O, S, UPS; Hepp, *Flechten Europas* 515), Heidelberg, ca. 1860-70 m, *W. Ahles* (STU); Bairenth, an einer Keuperfelsnand im Obernaizer Mühlgraben, 5.1861, *Arnold* (O, S; Arnold, *Exs.* 192); Bairenth, 24.6. 1866, *Arnold* (O, S; Arnold, *Exs.* 292b).- **GREAT BRITAIN:** Chanel Islands, La Molle, Jersey, 1873, *Larbalestier* (BM, UPS, W); Isla Wight, *Ventnor* (BM); Nesscliffe, Shropshire, *Leighton* (BM); Yorkshire, Cleveland, near Ayhm, *W. Mudd* (S), Cleveland, Ingleby Park, *W. Mudd* (S); Wales, between Arddog and Yynysfaig, on sandstone by the road, 1837, *T. Salwey* (NY).- **ITALIA:** Lombardia, Varallo, 1900, *Masi* (FH); sugli scisti di Val Intrasca, Lago Maggiore, *Baglietto* (S; *Erbar. Crittogam. Ital.* 429 (1429)).- **MOROCCO:** Tanger, Cabo Spartel, 30-100 m, sobre esquistos, 14.4.1984, *J. M. Egea* (MUB).- **PORTUGAL:** Estremadura, Cabo de Roca, steilflächen an der Küste, 21.3.1961, *J. Poelt* (GZU); Maderira, Ribeiro Frio, Levada hacia Balcöes, 700 m, 31.5.1988, *J. M. Egea* (MUB).- **RUMANIA:** Carpati, montes Capatini, in valle fl. Oltul, supra balneas Caciulata, ca. 700 m, ad saxa umbrosa in Fageto, 12.8.1970, *A. Vezda* (GZU, WIRTH).- **SPAIN:** Asturias, Oviedo, Desfiladero Rio Ponga N von Beleño, Concejo de Ponga, S von Cangas de Onís, 300 m, Silikatfelwände in Schlucht, 2.9.1980, *J. Hafellner* (HAFELLNER); Cádiz, Sierra de la Plata, 12.5.1983, *J. G. Rowe* (MUB); La Coruña, Caaveiro, Puentedeume, sobre esquistos, 19.4.1985, *M. E. López de Silanes* (MUB).- **USA: Alabama,** *T. M. Peters* (FH); **Missouri,** St. Clair Co., Buzzard Bluff above Sac River, ca. 4 mi SE of Roscoe, T.37N., R.26W., sect. 35, ca. 760-850 feet, oak-hickory forest at top gandstone bluff, 22.4.1988, *W. R. Buck* (NY).

11. Cresponea proximata (Nyl.) Egea & Torrente comb. nov.
(Figures 1A-B, 2C, 6)

Lecidea poximata Nyl., Ann. Sci. Nat. Bot., sér. 4, 19: 356 (1863).- *Lecanactis proximata* (Nyl.) Zahlbr., Cat. Lich. Univ. 2: 544 (1924). **Type:** Cuba, *C. Wright* (H-NYL 5423 p.m., lectotype here selected).

Lecidea concordans Nyl., Bull. Soc. Linn. Normandie, sér. 2, 7: 170 (1873), (non *Lecidea concordans* Nyl., Lich. N. Z. 108 (1888) = *Mycoblastus hypomelinus* (Stirton) Müll. Arg., *fide* Galloway 1985).- *Lecanactis concordans* (Nyl.) Zahlbr., Cat. Lich. Univ. 2: 534 (1923). **Type:** (India), Ins. Andaman, 1867, *S. Kurz* 77 (H-NYL 10827, lectotype here selected; W isolectotype).

Lecanactis macrocarpa Zahlbr., Bot. Mag. (Tokyo), 41: 315 (1927). **Type:** Japon, Kiushiu, Taradake, corticola, 10.6.1899, *Faurie* 1707 (W, lectotype).

Lecanactis limosescens Zahlbr., Feddes. Repert. 31: 224 (1933). **Type:** Formosa (Taiwan), Soozan prope Taihoku, ad corticem arboris sublaevem, 14.12.1925, *Y. Asahina* 174 (W, holotype).

Lecanactis leprieurii f. *brachyspora* Malme, Ark. Bot. 20(2): 2 (1926). **Type:** Brasiliae, Matto Grosso, Serra da Chapada, Buriti, 16.4.1894, *A. G. A. Malme* (UPS, lectotype here selected; FH, isolectotype).

Thallus whitish, greyish or greenish, continuous, cracked or areolate, thin, often delimited by a thin dark brown hypothalline line. In section up to 150 µm.

Ascomata scattered, sessile, constricted at base, 0,2-1,5(-1,8) mm, with a smooth or somewhat crenulate margin. Disc plane or slightly convex, with green, ochraceous-yellowish or reddish pruina, occasionaly epruinose. Hymenium 70-110 µm, I+ reddish. Subhymenium pale brown, 200-45 µm, I+ blue in parts/reddish. Paraphysoids up to 2 µm wide, in the hymenium; apical cells thickened (4-5 µm), with a distinct red brown cap wich is formed in the outer part of the cell wall. Asci 60-75 x 16-24 µm. Ascospores fusiform 25-38(-40) x 5-7(-7,5) µm, 5-7(-8) septate; cell walls not or little thickened at septa; cells of the middle of the ascospores are bigger than the rest.

Pycnidia immersed or subimmersed in the thallus, unilocular or secondarily multilocular, 160-210 µm tall, 200-250 µm wide. Conidia 4-6 x 1 µm, straight.

Distribution and habitat: *Cresponea proximata* is a Pantropical species. In the Paleotropics, it is mainly a Indo-Malesian element extending to Eastern Asia (China, Japan). In the Neotropics, it is known from Caribbean and Brazilian region. It has an altitudinal range from sea level to 1000 m. It has been found in lowland moist forest and mangroves, on *Cocos nucifera*, *Pasania*, *Podocarpus* and *Rhizophora mangle*.

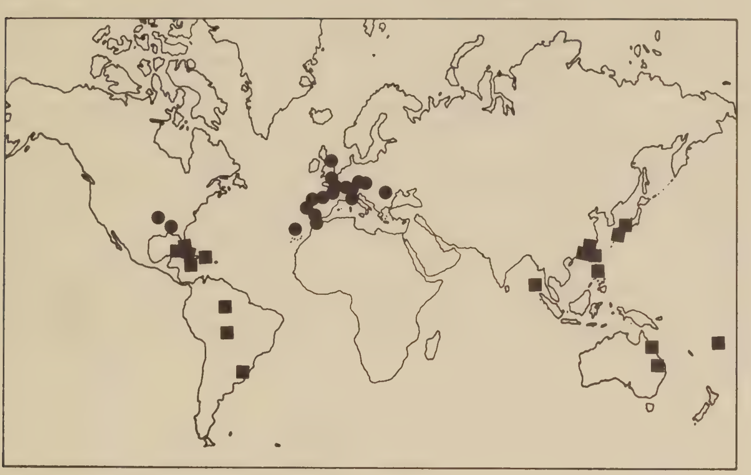

Figure 6. Distribution map of: *Cresponea premnea* var. *saxicola* (●) and *C. proximata* (■).

Notes: This species is close to *Cresponea leprieurii*, but it differs in having shorter asci and ascospores. On the other hand, *C. proximata* is similar to *C. plurilocularis*, which differs in having more septate ascospores, with widened septa.

In the protologue to *Lecanactis limosescens* (Zahlbruckner 1933) and *L. macrocarpa* (Zahlbruckner 1927), the ascospores measurements are 29-32 x 3-5 µm and 25-27 x 4-5 µm, respectively. Close examination of the type material of both taxa revealed a bigger size of the ascospores, 28-37 x 5,5-7 µm for *L. limosescens*, and (25-)28-31(-37) x 5-6 µm for *L. macrocarpa*. This size of ascospores are similar with the type material of *Lecanactis concordans* (28-33(-36) x 5-6 µm), *L. leprieurii* f. *brachispora* (30-40 x 6-6,5 µm) and *L. proximata* (29-38(-41) x 6-7,5 µm). No other significatively differences have been found between all these specimens.

Additional specimen examined: **AUSTRALIA:** Queensland: Shirley (W), Clarke Range, 46 km SSW of Proserpine, 20°49' S, 148°29'E, on sapling in "dry" rainforest with *Argyrodendron trifoliatum* & *A. actinophyllum* ssp. *diversifolium*, 600 m, 29.6.1986, *J. A. Elix* & *H. Streimann* (CBG).- **BRAZIL:** Matto Grosso, Sta Ana da Chapada, 23.2.1894, *Malme* (S); Rio Grande do Sul, Silveira, fur Santa Mariedo, 4.3.1893, *Malme* (S); along Rio Uatuma just E of Igarapé Tucumanduba, campina, 02°15'S, 59°04'W, 12.8.1979, *W. R. Buck* (NY).- **CHINA:** Hong Kong, *C. Wright* (FH); Fukien, Kushan near

Foochour, 500-600 m, 8.1926, *H. H. Chung* (FH).- **CUBA:** *C. Wright* 243 (FH); Province of Havana, Cojimar, on Cupania, 5.2.1916, *N. L. Britton, E. G. Britton, P. Wilson* (NY); Oriente, La Prenda, 12.1921, *B. Hioram* (NY).- **DOMINICAN REPUBLIC:** Prov. Pedernales, Las Abejas, 52 km N of port of Cabo Rojo on Alcoa road, humid *Podocarpus* dominated forest, 3800 feet, 7.5.1982, *W. R. Buck* (NY).- **INDIA:** Bengalia orientalis, prope Koosthea, Kurz 1866 (H).- **JAMAICA:** Montego Bay, 1912, *J. A. Cushman* (FH).- **JAPAN:** Awaji, Mukuma, on Pasania cuspidata, A. Yasuda 25.8.1912 (H); Kii, 7.11.1920, *A. Yasuda* (H); *C. Wright* (FH).- **PHILIPPINES:** Luzon island, Laguna, 60 Km SE of Manila, Los Baños, Mt. Makiling, Mud Springs, 300 m, on tree in forest, 2.1987, *A. Aptroot* (APTROOT).- **SAMOA:** Insel Upulu, mangrove, *Rechinger* (W), Apcaberg, ca. 300 m, auf Ficus, 5.1905, *Rechinger* (W).- **TAIWAN:** Nan-tou Co., Chi-tou Experimental Forest of Nat. Taiwan University, road sides, ca. 1200-1300 m, warm temperate rain forest zone, 18.10.1970, *T. Koponen* (H).- **USA:** **Florida:** Monroe Co, Totten's Key, 7.11.1901, *J. K. Small & G. V. Nash* (NY).

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MYCOTAXON

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CONIOPHORA DIMITICA CUNN. (CONIOPHORACEAE, BASIDIOMYCETES) IN ZIMBABWE

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ABSTRACT

Coniophora dimitica Cunn. is reported as new to Africa and described in culture for the first time. The diagnostic culture features were thick-walled brown skeletal hyphae, multiple clamps, cytoplasmic shrinking, hyphal constriction and wide rounded hyphae in the advancing zone. Extension growth experiments revealed that growth was optimum at 25 °C and inhibited at 37 °C. Linear extension growth was maximum at -0.5 MPa on both NaCl and KCl. Culture morphological features and physiological response pattern support the retention of the species in *Coniophora*.

KEYWORDS *Coniophora dimitica*, basidiocarp and culture features

INTRODUCTION

The genus *Coniophora* D.C.:Mérat comprises about a dozen species. Of the 10 species known to occur in Africa six have also been recorded in Zimbabwe (Masuka & Ryvarden, 1991). Species of the genus have large (8 µm and above), brown, dextrinoid, ellipsoid spores with a double wall, the inner being cyanophilous (Ginns, 1982). The spores have large apiculi. All the species have simple-septate monomitic hyphal systems except for *Coniophora dimitica* Cunn. and *C. mollis* Cunn. (Ginns, 1982). *C. dimitica* was described from New Zealand (Cunningham, 1963). Previously documented collections were made on dead branches of *Leptospermum ericoides* and *L. scoparium* (Myrtaceae), and *Pittosporum umbelatum* (Pittosporaceae).

C. dimitica is unique in *Coniophora* mainly because it possesses a dimitic hyphal system (Ginns, 1982). Cunningham (1963) erroneously reported the presence of setae in the species which on later closer inspection turned out to

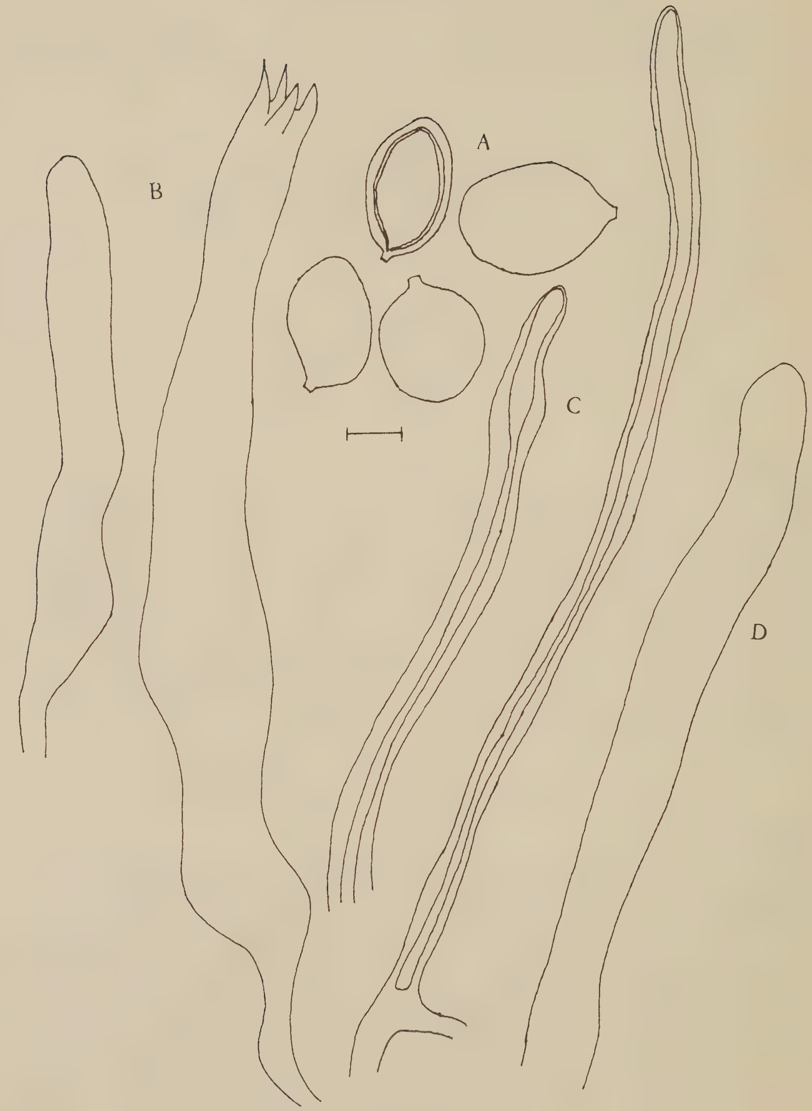

Figure 1. Diagnostic culture and basidiocarp morphological features; a) basidiospores, b)basidia, c) skeletal hyphae d), advancing zone hyphae,

be vertically oriented skeletal hyphae (Ginns, 1982). The latter author could not establish the reported (Cunningham, 1963) presence of septa at the base of skeletal hyphae. The retention of the species in *Coniophora* has been based entirely on the examination of basidiocarp morphological features. Ginns (1982) regarded the dimitic hyphal system as a taxonomic character not strong enough to warrant the creation of a new genus.

Recently several collections of the species were made on *Eucalyptus grandis* at two localities in Zimbabwe (Masuka, 1992). The basidiocarp morphological features have since been examined in some detail and the fungus has been isolated and studied in culture.

MATERIALS AND METHODS

Basidiocarp morphology

Macro- and micro-morphological features of the fungus were observed under Leitz and Medilux 12 Kyowa microscopes, respectively. The dextrinoid reaction was observed in Melzer's reagent while cyanophily was detected in 0.1% cotton blue in 60% lactic acid.

Culture morphological studies

Pieces of basidiocarp subiculum tissue were aseptically excised and cultured on 2 % (w/v) MEA in 9 cm petri dishes, with 2 mg/l benomyl added to suppress contaminants. Three replicates of the isolate were incubated at 25 ^{0}C in the dark for six weeks. Observations on morphology were made regularly. At the end of the incubation period pieces of mycelium were put in porcelain staining-plate depressions and syringaldazine and L-tyrosine enzyme spot tests conducted according to Marr (1979).

Temperature and osmotic potential

Three replicates (4 mm cubes) of one isolate were inoculated at the edges of petri dishes and incubated at 15, 20, 25, 30 and 37 ^{0}C. The incubators were accurate to 0.5 ^{0}C. Extension growth was measured along two diameters at right angles every two days for two weeks. The amounts of KCl and NaCl required to achieve a given osmotic potential were calculated following the formula of Koske and Tessier (1986), those of NaCl with osmolal adjustments (Masuka, 1992). Three replicates of the isolate were sub-cultured at each of seven osmotic potentials, -0.14, -0.5, -1.0, -1.5, -2.0, -2.5 and -3.0 MPa, and incubated in darkness at 25 ^{0}C for five days. Extension growth was measured along two diameters at right angles after the incubation period.

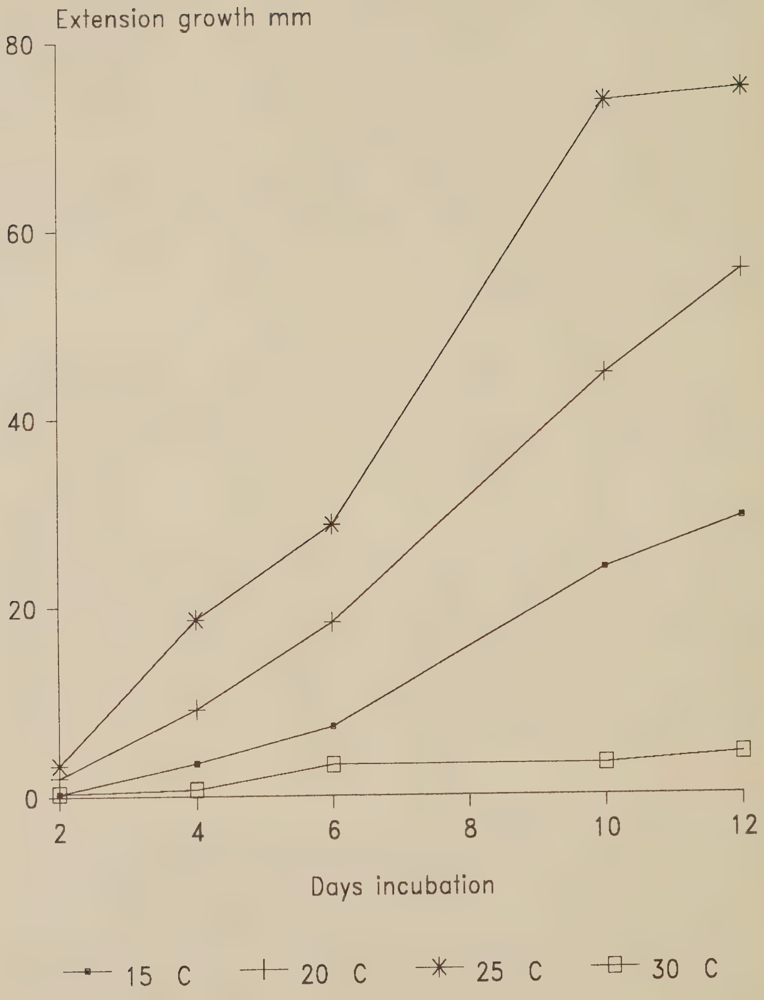

Figure 2. Growth of *C. dimitica* at various temperatures.

Distribution: known only from New Zealand (Cunningham, 1963) and Zimbabwe (Masuka, 1992).

Table 1. Spore dimensions of *C. dimitica* (n = 20)

Parameter	Spore length (μm)	Spore width (μm)
Mean	12.9	7.9
Median	12.5	7.5
SD	1.6	1.1
SE(mean)	0.4	0.2
95 % C.I.	(12.9, 13.0)	(7.8, 8.0)

Effect of temperature on growth

Growth was maximum at 25 ^{0}C and inhibited at 37 ^{0}C. Very little growth occurred at 30 ^{0}C (Figure 2). The average daily growth rates, calculated from the linear portions of the graph, are shown in Figure 3.

Effect of water potential on growth

Maximum growth occurred on KCl amended media (Figure 4). The respective water potential optima for growth on NaCl and KCl were -0.5 and -1.0 MPa. The response pattern on both media was similar. There was an initial increase in extension growth up to a maximum followed by a decrease in growth.

DISCUSSION

The general culture morphological features, and temperature and water potential response patterns of *C. dimitica* are similar to studied isolates of *Coniophora olivacea* (Fr.:Fr.) Karst. and *C. puteana* (Fr.) Karst. (Masuka, 1992). Most of the morphological features of the species are also similar to those of other *Coniophora* species (Ginns, 1982). The present studies add weight to the retention of *C. dimitica* in *Coniophora* despite the unique presence of a dimitic hyphal system and the velvety appearance of the basidiocarp. The cultural study also confirmed the occasional presence of septa at the bases of skeletal hyphae for which there were conflicting reports (Cunningham, 1963; Ginns, 1982).

C. dimitica is restricted to eucalypts in Zimbabwe. Such fungi were probably introduced on imported eucalypt material (Masuka & Ryvarden, 1992).

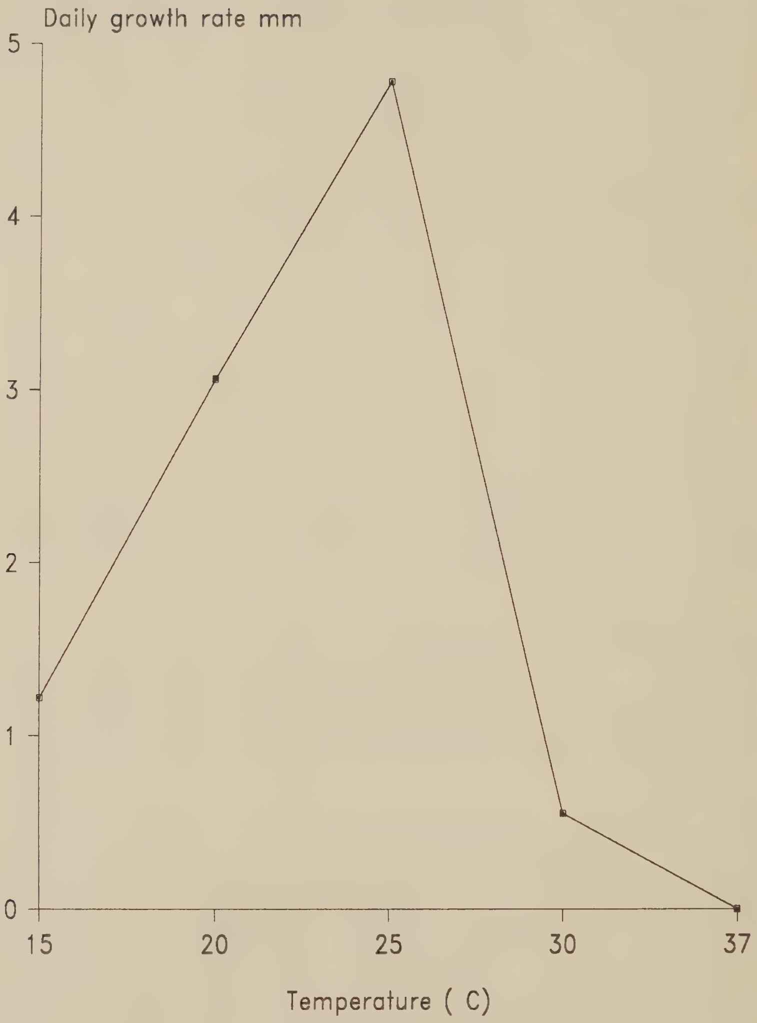

Figure 3. Average linear growth rate of *C. dimitica* at various temperatures.

RESULTS

Species description

Coniophora dimitica Cunn. *Trans. Roy. Soc. N. Z.* (1957) **84:** 495 Fig. 1

Basidiocarp annual, resupinate, smooth, membranous, separable, occasionally cracking in dry specimens, drab to brown, shiny when turned in incident light; context brown, up 8 mm deep; consistency soft and friable; margin paler, thin.

Hyphal system dimitic, generative hyphae simple-septate, hyaline to yellowish, thin- to moderately thick-walled, freely branched, 2-2.75 µm wide, cyanophilous; skeletal hyphae abundant, brown, thick-walled (0.5-0.75 µm), flexuous, mostly vertically oriented in hymenium, with a distinct lumen, inflated in sections, sometimes with dichotomous branching, the branches often tapering, 3.25-5(-7) µm wide.

Basidia four-sterigmate, sterigmata 5-7 µm long, utriform when mature, large, 8-10 x 40-60 µm, mostly collapsed in dry samples.

Basidiospores ellipsoid to oval, yellowish-brown to brown, immature spores sub-globose and hyaline to yellowish, dextrinoid, thick-walled, with a double wall, guttate, apiculus large and blunt, 7.5-9.75 x 11.25-15 µm. Some spore parameters are indicated in Table 1. Spore length to width ratio is 1.7 (n = 20).

Cultures whitish at 1-3 weeks, later brown in patches (Figure 2), some cultures covering Petri dishes in 10-14 days; mycelium prostrate, pellicular, floccose, sparse with hyphal strands developing after 3-4 weeks; growth radial; margin even, fimbriate, hyphae not submerged, slightly raised; a faint mushroom smell developing after 3 weeks; reverse unchanged at first, later becoming yellowish; without softening of agar; basidiocarps sometimes produced after 8 weeks.

Advancing zone hyphae thin-walled, hyaline, simple-septate, occasionally with 2-8 clamps, with rounded endings and of several types, (a) broad hyphae (9-16 µm wide) with terminal cells up to 350 µm and broad rounded occasionally moniliform ends, (b) thin hyphae (2-3 µm wide), straight, unbranched, arising from clamps or not, (c) hyphae mostly 7-12 µm with, multiple branches.

Rear zone hyphae simple septate, with occasional verticillate clamps, hyaline to yellowish brown, thin to moderately thick-walled, freely branched, some hyphae with external droplets, 2-6 µm wide; skeletal hyphae produced after 3 weeks, arising from generative hyphae, with occasional septa at the bases, thick-walled (0.5-0.75 µm), brown, straight to sinuous.

Type of rot: brown-rot, no change observed after 15 and 60 minutes with syringaldazine and L-tyrosine spot tests.

Habitat: *C. dimitica* basidiocarps are quite common on burnt bark of *E. grandis*.

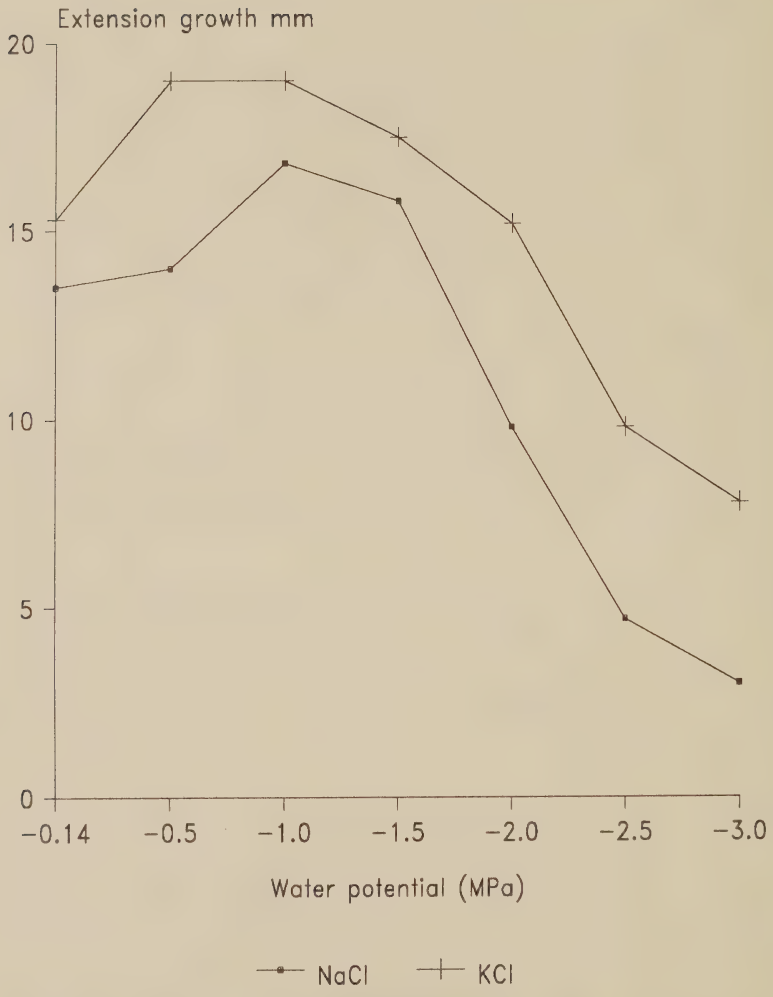

Figure 4. Effect of NaCl and Kcl induced water potential on the growth of *C. dimitica*.

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NOTES ON THELEBOLUS MICROSPORUS ISOLATED IN ANTARCTICA

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ABSTRACT - The present study was undertaken to compare isolates of *T.microsporus* (Berk. et Broome) Kimbrough from the Antarctic continent and various parts of the world in order to redefine the species according to morphological, cultural and physiological characteristics. Type specimen, Antarctic strains and exsiccata were examined and the species description is amended. The taxonomic position of the genus is presented.

KEY WORDS: *Thelebolus microsporus*; amended diagnosis; Victoria Land (Antarctica).

INTRODUCTION

During a study on the occurrence of fungi in soil, mosses, mud of ponds and ornithogenic material collected in Victoria Land (Antarctica), a minute 8-spored ascomycete was frequently recorded (Del Frate and Caretta, 1990; Montemartini Corte, 1990, 1991; Onofri et al., 1991). The morphological characteristics of numerous isolates agree with the descriptions of *Thelebolus microsporus* (Berk. et Br.) Kimbr., but differ from the type specimen in the size of ascoma and ascus. A comparison of our isolates with *Thelebolus microsporus* previously identified by various workers was made and the results of these studies are presented below.

MATERIALS AND METHODS

Observations were made on living strains of *Thelebolus microsporus* isolated in the Antarctic continent, on strains of *T. microsporus* available at the Centraalbureau voor Schimmelcultures, Baarn (CBS), on herbarium specimens available at the Royal Botanic Gardens Kew, Surrey (K), at the International Mycological Institute, Ferry Lane, Kew, Surrey (IMI) and at the herbarium of Istituto Botanico, Università di Pavia (PAV).

Herbarium material was softened in water and in lactophenol prior to mounting. Measurements were made of ascomata, paraphyses, asci and ascospores mounted in lactic acid, lactophenol cotton blue or lactophenol acid fucsin.

Growth studies of living strains of *Thelebolus* obtained from single ascospores were conducted on carrot agar, V-8A (15% V-8 juice agar), Czapek-Dox agar, Leonian yeast agar and malt extract agar (2%).

Growth rates, variability and colour of colonies (Fig.1), induction of teleomorph formation were recorded from cultures on the media mentioned above ; Leonian yeast agar and malt extract agar (MEA) often did not produce fertile ascomata.

Measurements were made of 25 ascomata, 50 asci and ascospores of each strain; given sizes represent the average of these measurements.

To study temperature requirements, the strains were incubated at -20°, 0°, 5°, 15°, 20° and 25°C in 90 mm diam. Petri dishes for 30 days or more (90 days for -20°C) some in darkness, others exposed to fluorescent light.

The specimens of *T. microsporus* isolated by us in Victoria Land (72°-75° S lat., 162°-169° E long.) were encountered in the localities and substrates listed in

Tab. 1.

Fresh and dried cultures examined :

Fresh: *Thelebolus microsporus* (CBS 734.68) isolated in Antarctica from soil collected within a skua nesting area. Hallet Station, Nov.1, 1966, O.L.Lange.
T.microsporus (CBS 115.53) ex *Lactuca sativa.*
T.microsporus (CBS 716.69 ; IMI 144.391) ex deer dung, D. Malloch.

Dried: *T.microsporus* (IMI 144.392; IMI 144.394) isolated from wolf dung, Circle Lake, Ontario, Canada, R.F.Cain, July, 29, 1965.
Ascophanus subfuscus (IMI 144.384) isolated from wolf dung, Circle Lake, Ontario, Canada, R.F.Cain, July, 29,1965.

European (1) and Australian (2) exsiccata examined:

1)European:

1) *Ascobolus microsporus* Berk. et Broome, on cow dung, Batheaston, Nov.19, 1864 (type), (K), (Fig.3).
2) *A.microsporus* Berk. et Br., on cow dung, Langley Wilts, Dec. 1804 (sic! or 1864?),(K).
3) *A.microsporus* Berk. et Br., Batheaston; Rabenhorst, Fungi Europaei N°977 (PAV).
4) *A.microsporus* Berk. et Br., Kings Cliffe, Oct. 1865,(K).
5) *A.microsporus* Berk. et Br., Batheaston, Nov.4, 1865.(K).
6) *A.microsporus* Berk. et Br.,1865,(K).
7) *Ascobolus subfuscus* Phil. (sic!) on the ground. Shrewsbury; N° 657 M.C.Cooke, Fungi Britannici Exs., Ed. secunda, (PAV).
8) *Ascophanus microsporus* (Berk. et Br.) Phill., Forden, Sept. 1876,(K).
9) *Ascophanus microsporus*, on sheep dung, Warby Oct. 15, 1878,(K).

Tab. 1. - Localities and habitats in which colonies were isolated.

Terrestrial localites	**Colonies**	**Material supporting colonies**
Edmonson Point	++++	penguin dung
Edmonson Point	++++	skua (Stercorariidae) dung
Inexpressible Island	++	penguin dung
Kay Island	+	petrel (Procellariidae) dung
Kay Island	+	petrel feather
Aquatic localities		**Biological characteristics of ponds**
Edmonson Point (lake 14)	++++	Phytoplancton present. Near penguin nests and frequented by skuas
Eneide lake	++++	Near the Italian base, frequented by skuas
Carezza lake	+++	Phytoplancton present, frequented by skuas
Gondwana pond	+++	Near the German Base, frequented by skuas
skua lake	+++	Frequented by skuas
Crater Cirque lake	++	Phytoplancton present, frequented by skuas
Edmonson Point (lake 15)	+	Phytoplancton present, frequented by skuas
Baker Rock pond	+	Frequented by few skuas
Tarn flat pond	-	Skua not observed

LEGEND:	++++	Abundant colonies: samples from many years.
	+++	Abundant colonies: samples from many years.
	++	Few colonies: samples from two years.
	+	Few colonies: samples from only one year.
	-	Only one colony: samples from only one year.

10) *Ascophanus microsporus*, on cow dung, N.Halifax, H.T.Soppett Oct. 17 or 24, 1898,(K).
11) *Ascophanus microsporus*, on fox(?) dung, Hayfield, J. T. Palmer, April, 1, 1961, (K).
12) *Ascophanus subfuscus* Boud., supra fimum humanum hieme et vere, Amager. E.C. Hansen; N°2019 Rabenhorst, Fungi europaei, (PAV).
13) *Ascophanus subfuscus* Boud., in stercore humano exsiccato. Pavia, estate 1888 F.Cavara; N°175 Collectio Agri Ticinensis, Herb. Horti Tic. (PAV).
14) *Ascophanus microsporus* (Berk.et Broome) Phill.,on cow dung, Brochel, Raasay, R.W.G.Dennis, Sept. 8, 1976, (K).
15) *Thelebolus microsporus* on cow dung. South Devon, M.C.Clark, Oct. 19, 1979 (IMI 244723).

2)Australian:

16) *Thelebolus microsporus*, wombat dung, Warrenbayne, H.A.Dade, Sept, 14, 1963 (IMI 104303 b).
17) *Thelebolus microsporus*, sheep dung, Macquaire Is. (North Head), R.Filson, March, 18, 1964, (IMI 108525c).

RESULTS

Growing hyphae from germinating ascospores quickly form a mycelium. In four days the initial stages of ascomata appear (Fig.4). Colonies reach 2-3 cm diam. in ten days at 15°C on the media reported above. The cultures produce ascomata in all media within two weeks, but they were more abundant and fertile on carrot agar. The monosporic strains produce ripe ascomata in 10-12 days, which often have light walls early dissolving .

Optimal temperature for growth was 15 °C at pH 5.5; in 40 days considerable growth occurs at 0° C , no growth occurs at 25°C and at -20° C, but the strains survive. Ascomata are scattered to gregarious, sometimes confluent, superficial, globose (Fig.2) later becoming apothecioid, glabrous, rising from the substrate or on aerial hyphae, 40-150 μm diam., hyaline to pale orange brown.

Asci clavate about 17.5-42.5 x 6.5-10 μm, 8-spored; ascospores biseriate, ellipsoidal, paraphyses slender with much inflated apices.

Our strains have been compared with *T.microsporus* strains CBS 734.68, CBS 115.53, CBS 716.69 , as well as with the type *Ascobolus microsporus* Berk. et Br. and specimens and exsiccata coming from cold and temperate areas. Morphologically *Ascobolus microsporus* collected at Batheaston by Berkeley and Broome (Fig.6) is similar to our antarctic strains and to antarctic CBS 734.68, but ascomata and asci of the Antarctic strains are smaller in size and often have thinner walls (Fig.9). Among other strains, CBS 115.53 is similar to ours but with poor asci production, CBS 716.69 is sterile. Among dried cultures, *T.microsporus* labelled 144.392 IMI, 144.394 IMI isolated by Cain in Ontario, have ascomata very similar to ours but sterile, whereas the dried culture labelled *Ascophanus subfuscus* 114.384 IMI also by Cain (Ontario), already cultivated on PCA, is like our strains, with typical ascospores, but with almost always diffluent asci. The measurements from the antarctic strains and from the dried cultures from Ontario is reported in Tab.2.

The analyses of exsiccata and slides coming from temperate regions of Europe and Australia (all K and PAV exsiccata and IMI 247.723, IMI 108.525c, and IMI 104.303) often reveal monoseriate spores (Fig.7) and ascomata with measures corresponding to the ones described for the species. Data referring to exsiccata and slides of European and Australian specimens are collected in Tab. 3. Comparing Tab. 2 and 3 and Fig. 7 and 9, it can be noted that the asci of Antarctic strains are clavate and often shorter and broader, with biseriate ascospores, the strains of temperate zones have elongated asci often with monoseriate ascospores.

Tab. 2. - Measures (min-med-max) of reproductive structures referring to anctartic strains and dried cultures from Ontario. Maximum and minimum values referring to the length of asci are absolute, while width values are relative to the same asci which show those absolute extreme values in length. Measures are in µm.

	ascomata			asci			ascospores		
	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX
Terrestrial localities (aver. among more strains)	75	100	120	17.5x6.5	22x7.7	25.3x8	5.1x3.1	6.5x4	8.1x4.5
Edmonson Point lakes (aver. among more strains)	40	77	150	21.2x8	25.3x7.8	40x8	4.6x3.1	7x4.1	8.5x4.6
Eneide Pond (aver. among more strains)	51	82.5	137	22.5x7.5	27.2x7.7	40x7	5.2x3.1	6.9x3.9	9.1x5.2
Carezza lake (aver. among more strains)	70	95	149	30x7.5	34.2x7.6	42.5x6.8	5.5x3.1	7.4x3.8	8.1x4.7
Gondwana pond (aver. among 2 strains)	45	68.5	95	27.5x10	30.8x8.7	37.5x7.5	5x2.5	6.5x3.5	7.8x4.5
Crater cirque lake (aver. among 2 strains)	50	65.2	117	22.5x8	29.5x7.1	37.5x7.5	5.4x2.5	7.4x3.7	9.4x4.7
Skua lake	42	68.5	102.5	28.7x8	34.8x7.6	42.5x7.5	5.4x3	7.5x3.8	9.4x4.5
Baker rock pond	45.7	61.6	82.5	26.2x8	33.9x8.4	37.5x7.5	6.2x3.8	7.3x4.6	7.8x6.5
Cain (Ontario) IMI 144392	62	85	100	---	---	---	---	---	---
Cain (Ontario) 144384	---	---	---	---	---	---	6x4	6.8x4.6	7.8x5.5

Tab. 3. - Data referring to European and Australian specimens. Some of the specimens examined did not show the reproductive structures or had not enough material to calculate the average values. Maximum and minimum values referring to the length of asci are absolute while width values are relative to the same asci which show those absolute extreme values in length. Measures are in µm.

Exsiccata or slides	ascomata			asci			ascospores		
	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX
Ascobolus microsporus Berk. et Br. Batheaston, TYPE	115	---	187	31.2x8.5	38.4x8.2	50x7.5	7.1x3.2	8.1x3.5	10.5x4.2
Ascobolus microsporus Berk. et Br. Batheaston, Rabenh., Fungi Europ. 977	125	---	185	32x9.5	49x7.7	62.5x6.5	7.8x3.4	8.8x4	10.1x5.9
Ascobolus microsporus Berk. et Br. Kings. Cliffe	34	78.6	120	36.5x10	41.9x8.7	52.5x7.5	6.4x3.2	7.8x4.2	9.4x5.5
Ascobolus microsporus Berk. et Br. Batheaston, 4 Nov. 1865	---	---	---	37x10	---	44x7.5	---	---	---
Ascobolus microsporus Berk. et Br.	---	---	---	32x7.5	---	38.7x 5.6	---	---	---
Ascobolus subfuscus Phil. M.C. Cooke Fungi Brit. Ed. Sec. 657.	80	---	115	---	---	---	6.2x3.1	7.4x4	8.1x4.7
Ascophanus microsporus (Berk. et Br.) Phill.	100	---	137	---	---	---	---	---	---
Ascophanus microsporus, on sheep dung, 1878	100	---	130	---	---	---	---	---	---
Ascophanus subfuscus Boud, Rabenh. Fungi Europ. 2019	85	---	125	---	---	---	6x3.5	---	6.5x4.5
Ascophanus subfuscus Boud, Coll. Agri Tic. 175	80	110	135	39x9.3	---	56x10.9	7.8x3.4	9x5.1	10.9x6.2
Ascophanus microsporus (Berk. et Br.) Phill. Dennis, 1976	205	---	237.5	45x6.5	54.6x7.3	61x8.7	---	---	---
Thelebolus microsporus, South Devon, M.C. Clark	---	---	---	40x9.5	---	47.5x6.7	---	---	---
Thelebolus microsporus, Warrenbayne, Australia IMI 1087 25 (C)	---	---	---	37.5x8.7	43.7x7.5	55x7.4	5.8x3.8	7.4x4.1	9.2x4.5
Thelebolus microsporus, Macquaire, Australia IMI 104303 (b)	---	---	---	40x9	42x7.1	62x6	---	---	---

The slight difference in the size of spores perhaps is due to the different degree of maturity of exsiccata compared with fifteen days old cultures of the Antarctic strains examined.

DISCUSSION

Ever since Kimbrough after various studies (1966 and 1967 with Korf) transferred *Ascobolus microsporus* described by Berkeley and Broome (1865), to *Thelebolus* (fide Dennis 1981), this octosporeus ascomycete has not been treated by other workers.

Although *T. microsporus* is relatively common in some temperate areas, it is the only coprophilous species of the genus *Thelebolus* occurring in the Antarctic territory. Most *Thelebolus* species are generally coprophilous and psychrophilous and the occurrence of fructification in nature is related to seasonal low temperature (Wicklow and Malloch 1971); in most *Thelebolus* species the optimum temperature for growth is 15-20°C, in *T.microsporus* it is 15°C.

Delimitation of species within *Thelebolus* is very difficult; the asci and ascospore number, the ascoma size and colour may be variable (Kimbrough and Korf 1967). Morphological variability in ascomata and ascus size was also observed by us in numerous strains and in specimens examined of *T.microsporus*.

Samuelson and Kimbrough (1978) examined the morphology, development and cytochemistry of the ascus wall and its apical apparatus in different species of *Thelebolus*, each having a different spore number per ascus. The ascus differs in size, shape and number of ascospores among the various species, but the apical apparatus is notably similar. They observed that the wall structure very closely resembles that of the bitunicate ascus. *Thelebolus* ascus does not possess a true operculum and suboperculum (Samuelson and Kimbrough 1978). Ascal dehiscence occurs by an irregular break at the tip of the wall (Fig.8). *Thelebolus microsporus* was described as having cylindric mature asci (50-65 x 6.5-10 µm) whose apical region has thick walls and an area below the tip (Fig. 5) delimiting the apical ring (Samuelson and Kimbrough 1978).

The only distinctive morphological characteristics of *T. microsporus* strains isolated in Antarctica compared with the type specimen as well as with other specimens collected in the "locus classicus" and also with specimens found in other regions, are the small size of ascomata (40-150 µm) and the dimensions and the shape of asci (17.5 x 6.5 to 42.5 x 10 µm) and the thickness of their walls.

The difference in size of ascomata and asci in all our isolates referred to *T. microsporus* and the measures of this species based on literature and on original specimens are not sufficient to distinguish varieties not with standing the great variability of those characters and the similarity of the other ones. Accordingly, *T.microsporus* is mantained here as only one species, but it seems suitable to amend the diagnosis as follows:

THELEBOLUS MICROSPORUS (Berk. et Broome) Kimbrough em. nobis.

Ascomata gregaria, superficialia vel in hyphis aereis, sphaerica, sessilia, primum cleistothecioidea dein dehiscentia orbiculata, parva, albo-rosacea usque ocracea 40-250 µm diam. pro substrato et caeli varietate.

Asci octosporei, crasse clavati usque cylindracei, breviter stipitati, 17.5-65 x 5-10.9 µm pro stato caeli; cum sporis monostichis vel distichis exsilientibus per apicem rotundatum, crassiorem factum ob anulum interiorem.

Paraphyses saepe adsunt, filiformes apice plerumque leniter clavato-incrassatae, rectae vel curvae, hyalinae usque dilute luteo-virides.

Sporae ellipsoideae, laeves (4.6)-7.5-(10.9) x (2.5)-3.6-(6.5) µm, hyalinae, rectae, tunicatae.

Habitat: in solo, lacusculi limo et stercore.

Conservatio et fructificatio: in agaro cum radicibus Dauci coctis crescit.

Locus typi: Batheaston, Britannia.

Ascomata gregarious, superficial or borne on aerial hyphae, spherical, sessile, at first with cleistothecioid aspect then apothecia, white-pink to ochraceous, small (40-250 μm diam.) according to substrate and climate.

Asci octosporous, shortly stipitate, broadly clavate to almost cylindrical according to environmental conditions, 17.5-65 x 5-10.9 μm, with monostichous or distichous ascospores released through an irregular break of the apical dome sometimes showing a thickened internal ring.

Paraphyses often present, filiform, usually slightly clavate at the apex, straight or curved, hyaline to yellow-greenish.

Ascospores ellipsoidal, smooth, hyaline, straight, tunicate, (4.6)-7.5-(10.9) x (2.5)-3.6-(6.5) μm.

Substrate: soil, dung and pond mud.

Conservation and fructification on carrot agar.

Distribution: cosmopolitan (Europe, America, Australia and Antarctica).

Locus typi: Batheaston (England).

The first isolation of *T.microsporus* in Antarctica was made from soil collected within a skua nesting area, at Hallet Station (Nov.1, 1966, O.L.Lange CBS 73468). It was found by us on soil, on petrel, skua and penguin dung, but also more frequently it was encountered in lake mud samples. The survival of this species under Antarctic conditions, must be related to the ecological adaptability of the fungus. Among the ways possibly adopted in cold regions by fungi for their survival, Savile (1972) pointed to the simplification of life cycle by the suppression of the conidial state (anamorph) of the fungus. *Thelebolus microsporus* has not the anamorph form and this feature may justify its survival in Antarctica.

There are two tendencies about the systematic position of the genus *Thelebolus:* Eckblad (1968) and Eriksson (1981, 1984) considered it to belong to the order Pezizales (Discomycetidae), while Samuelson and Kimbrough (1978) and Kimbrough (1981) attributed it to the Loculoascomycetes because of the bitunicate asci.

It is difficult to add fresh arguments, but we noticed that the "jack-in-the-box" manner of dehiscence is evident in some of our strains too (chiefly the monosporic ones: our strain IMI 340.093) and this fact seems to support the Samuelson and Kimbrough thesis. On the other hand the same authors observe that the "extension of inner layer is sharply reduced" in *Thelebolus* and they hesitate to place the genus into a family of Loculoascomycetes (1978).

In Antarctica the development and the evolution of the living beings is restricted to the short summer: at low temperature they only survive; therefore species may keep primitive characters for a long time.

So we believe that *Thelebolus*, because of its primitive characters, could be considered at the base (Eckblad, 1968) of Pezizales; and, at the same time, the species *T.microsporus*, "most primitive" among the Loculoascomycetes because of its onthogeny and 8-spored asci (Kimbrough,1981), might represent the link between the two primitive groups.

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FIGURES

Fig.1 - Twenty days old colonies from dilution mud of Gondwana Pond (carrot agar).

Fig.2 - Detail of Fig. 1 : ascomata.(60 X).

Fig.3 - Type : photo of the original specimen (K).

Fig.4 - Initial stage of four days old ascomata of a strain isolated from dung in Victoria Land. (1000 X).

Fig.5 - Ripe ascus with thickened apical dome and apical ring (arrow). From exsiccata Rabenhorst Fungi Europ. 977 (PAV).(630 X)

Fig.6 - Type: asci and paraphyses. (400 X).

Fig.7 - Asci of *Ascobolus microsporus*(Berk. et Br.) Phill. From R.W.G. Dennis 1976 (K).(400 X).

Fig.8 - Type: break of ascus apical region (arrow). (400 X).

Fig.9 - Thirteen days old ripe ascomata with disintegranting walls, from Eneide Lake. (400 X).

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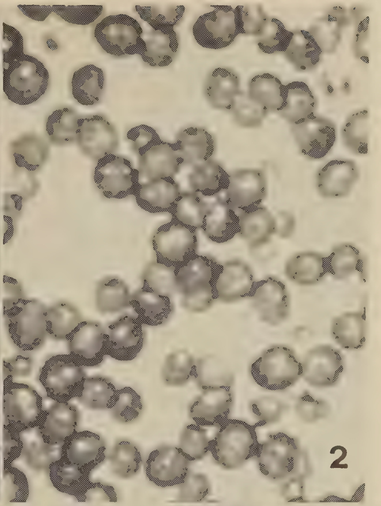
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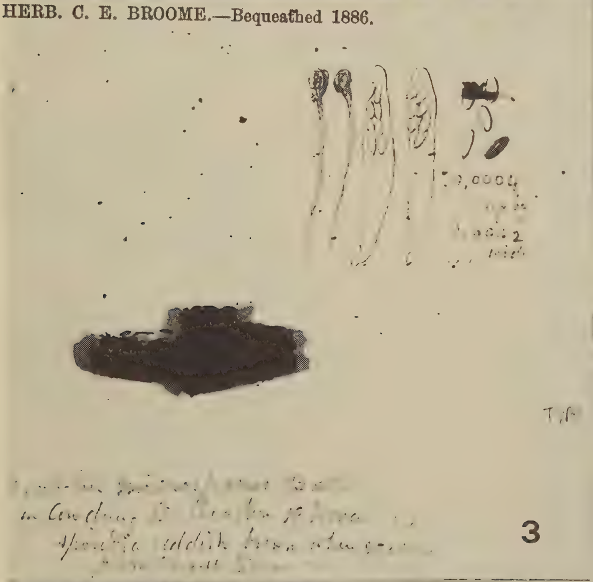
HERB. C. E. BROOME.—Bequeathed 1886.
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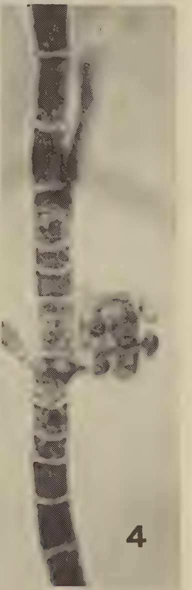
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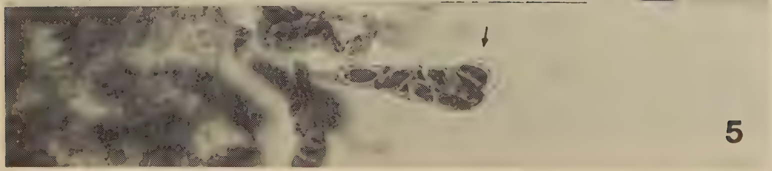
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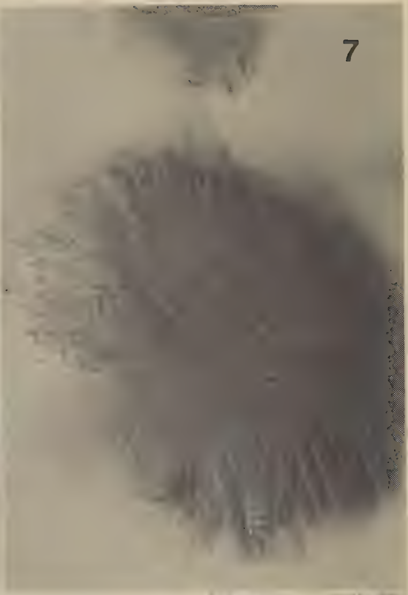

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ADDITIONS TO THE LICHEN FLORA FROM THE STATE OF JALISCO (MEXICO)

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SUMMARY

Twenty one species of lichens belonging to the genera *Cryptothecia, Dermatocarpon, Lobaria, Leptogium, Pannaria, Cetraria, Flavoparmelia, Hypotrachyna, Parmotrema, Pseudoparmelia, Punctelia, Rimelia, Heterodermia* and *Lepraria* are discussed as a new records from the State of Jalisco, Mexico.

RESUMEN

Se discuten 21 especies de líquenes adscritos a los géneros *Cryptothecia, Dermatocarpon, Lobaria, Leptogium, Pannaria, Cetraria, Flavoparmelia, Hypotrachyna, Parmotrema, Pseudoparmelia, Punctelia, Rimelia, Heterodermia* y *Lepraria* como nuevos registros para el Estado de Jalisco, México.

INTRODUCTION

As a continuation on the lichen research in the State of Jalisco (Guzmán-Dávalos and Alvarez, 1987; Alvarez and Guzmán-Dávalos, 1988), discussions on 21 species new for the State are presented. The known distribution in Mexico of each species is also included.

The studied material corresponds to 36 specimens from 16 localities of Jalisco, deposited in the Herbarium of the Instituto de Botánica at University of Guadalajara (IBUG), with some duplicates in the Herbaria of the Instituto de

Ecología (XAL), in the Escuela Nacional de Ciencias Biológicas of the Instituto Politécnico Nacional (ENCB) and in the Universidad Autónoma del Estado de Morelos (HEMIM). Identifications were made following the standard criteria for thallus study, including spore observation, lichenic acid determination and macrochemical tests of cortex and medulla with potassium hydroxide (K) and calcium hypochlorite (C). Species determination was principally based in Kurokawa (1962), Taylor (1968), Hale (1975, 1976, 1979, 1990), Galloway (1985), Swinscow and Krog (1988) and Thor (1991).

STUDIED SPECIES

ASCOLICHENS
OPEGRAPHACEAE

Cryptothecia rubrocincta (Ehrenb.) Thor, The Bryologist 94: 280, 1991.
= *Chiodecton sanguineum* (Sw.) Vain., Acta Soc. Fauna Fl. Fenn. 7: 143, 1890.

Corticolous, subfoliose, loosely attached to substratum. Upper surface with greenish-gray and red concentric zones, densely granular isidiate. Lower surface reddish, cortex lacking. Apothecia lacking. Cortex K+ purple. This species has been reported from Mexico by Dávalos et al. (1972), Castorena (1981) and Thor (1991) from the States of Hidalgo, Oaxaca, Puebla and Veracruz, and it is a very common element in the humid subtropical forests of the country (Guzmán, pers. comm.).

Specimens examined. km 24 Puerto Vallarta to El Tuito road, González Villarreal 3516 (IBUG).

VERRUCARIACEAE

Dermatocarpon miniatum (L.) Mann., Lich. Bohm. Obs. Dispos. 66, 1825.
Figs. 1 & 7

Thallus whitish gray to pale brownish gray. Perithecia and pycnidia present in upper surface. Common on rocks. It was reported by Bouly de Lesdain (1914, 1929 and 1933), Gibert (1935), Imshaug (1956), Hale (1969) and Brizuela & Guzmán (1971) from Baja California, Hidalgo, Morelos, D.F., Michoacán, Querétaro and north of Mexico.

Specimens examined. San Miguel El Alto to San Julián road, 20 km approximately SW of San Miguel El Alto, Alvarez 289 (IBUG). Region of Tala, Valle de Las Tortugas, Martínez 16 (IBUG). Region of Guadalajara, Barranca de Huentitán, Alvarez 106 (IBUG, ENCB); Gutiérrez s.n., Jun. 27, 1987 (IBUG, XAL); Figueroa 26 (IBUG); km 1-2 road to Puente de Arcediano, Alvarez 205 (IBUG, HEMIN). km 22 Zapotlanejo to Tototlán road, Alvarez 79 (IBUG). Region of Casimiro Castillo, El Tigre, Medina 12 (IBUG).

LOBARIACEAE

Lobaria quercizans (Ach.) Michx., Fl. Boreali-Am., 324, 1820.
Fig. 2

Thallus yellowish-brown to light gray, up to 90 mm broad. Lower surface tan, felty. Apothecia common, with crenate rim. Medula C+, KC+ rose (gyrophoric acid). It has been reported from Mexico by Imshaug (1956) without precise locality.

Specimens examinated. Sierra de Manantlán, Region of Autlán, Predio Las Joyas, El Laurelito, Guzmán-Dávalos 2949 (IBUG, ENCB).

COLLEMATACEAE

Leptogium furfuraceum (Harm.) Sierk., The Bryologist 67: 266, 1964.

This species is characterized by the striate upper surface, brown isidia with a small hole in the apex and rhizines compound by elongate cells on the lower surface. It was only known from the State of Tlaxcala (González de la Rosa & Guzmán, 1976) and Guerrero (Villanueva, 1983).

Specimens examined. Nevado de Colima slopes, kms 2-3 El Floripondio to Microwave Station road, Alvarez 567 (IBUG).

PANNARIACEAE

Pannaria rubiginosa (Ach.) Del., Dict. Class. Hist. Nat. 13: 20, 1828.
Fig. 3

Thallus closely adnate, whitish-gray or cream gray. Upper surface with pruina at the margins. Lower surface black with a narrow whitish zone at the margins, rhizines black and with tomentum projecting from the margin up to 2 mm. Apothecia common. Alga blue green. Cortex and medulla K-, C-. Spores 13-16 X 9-7 μm (Swinscow and Krog, 1988, considered spores 18-22 X 10-13 μm). Bouly de Lesdain (1929, 1933), Gibert (1935), Ruíz Oronoz (1936) and Imshaug (1956) reported this species from D.F. and Hidalgo. *P. rubiginosa* var. *conoplea* (Pers.) Nyl. was reported by Bouly de Lesdain (1914) from D.F.

Specimens examined. km 8 Tequila to Volcán de Tequila road, Guzmán-Dávalos 2470 (IBUG). Road to Santa Ana, near to San Sebastián del Oeste, Alvarez 139 (IBUG). km 6 La Manzanilla de la Paz to Mazamitla road, Trujillo 839 (IBUG). Sierra del Halo, km 16 Tecalitlán to Jilotlán road, Alvarez 270 (IBUG, ENCB).

PARMELIACEAE

Cetraria fendleri (Nyl.) Tuck., Gen. Lich. 33: 1872.
Figs. 4 & 8

Thallus foliose, up to 70 mm broad, lobes finely dissected at the tips, isidia marginal. Apothecia common, the rim isidiate. Cortex K-; medulla C- (fatty acids). This species has been reported by Bouly de Lesdain (1933) from D.F., Imshaug (1956) without precise locality and Hale (1969) from north of Mexico.

Specimens examined. Road to Santa Ana near to San Sebastián del Oeste, Alvarez 119 (IBUG, ENCB, XAL); Guzmán-Dávalos 4027 (IBUG).

Flavoparmelia caperata (L.) Hale, Mycotaxon 25: 604, 1986.
=*Parmelia caperata* (L.) Ach., Meth. Lich., 216, 1803.
=*Pseudoparmelia caperata* (L.) Hale, Phytologia 28: 189, 1974.

Thallus pale yellowish-green, wrinkled, with abundant laminal soredia. Common on trees. Medulla K-, C- (caperatic acid). Eckfeldt (1890-1895), Bouly de Lesdain (1933), Imshaug (1956), Hale (1969, 1976), Dávalos et al. (1972), Vargas (1973), Castorena (1981), Coutiño & Mojica (1982) and Gómez Peralta (1992) reported this species from Michoacán, D.F., Hidalgo, Oaxaca, Nuevo León and Puebla, but probably they reported a complex of species close to this species.

Specimens examined. Region of Lagos de Moreno, 3 km N from Rancho Jala, Arreola 819-A (IBUG).

Hypotrachyna imbricatula (Zahlbr.) Hale, Smithsonian Inst. Cont. Bot. 25: 41, 1975.
= *Parmelia imbricatula* Zahlbr., Zahlbruckner 168, 1909.

This species presents the upper surface with isidia simple to scarcely branched and with dark apices. Medulla K-, C+ orange (barbatic acid). It has been reported from Chiapas, Michoacán, Oaxaca, Sinaloa and Veracruz by Hale (1975) and from Guerrero by Antonio (1985).

Specimens examined. Sierra de Manantlán, Region of Autlán, Predio Las Joyas, El Laurelito, Guzmán-Dávalos 2947 (IBUG, ENCB, HEMIM, XAL). Sierra del Halo, km 16 Tecalitlán-Jilotlán road, Alvarez 268 (IBUG).

Hypotrachyna revoluta (Flk.) Hale, Smith. Contr. Bot. 25: 60, 1975.
= *Parmelia revoluta* Flk., Dtsch. Lich. 1: 11, 1815.

It is defined by the upper surface with marginal soralia, making an involute edge and by rhizines dichotomously branched. Cortex K+ yellow (atranorin); medulla K-, C+ rose (gyrophoric acid). This species has been reported by Bouly de Lesdain (1929), Gibert (1935), Imshaug (1956) and Gómez Peralta (1992) from Michoacán, Hidalgo and D.F.

Specimens examined. Around Mazamitla town, Guzmán-Dávalos 3767 (IBUG, ENCB, XAL).

Hypotrachyna rockii (Zahlbr.) Hale, Smith. Contr. Bot. 25: 62, 1975.
= *Parmelia rockii* Zahlbr., Annls. Mycol. 10: 379, 1912.

Lobes dichotomously branched, with truncated pustular sorediate apices. Medulla K-. It was reported by Hale (1971, 1975) from Chiapas, Michoacán and Puebla and by Antonio from Guerrero.

Specimens examined. Volcán de Tequila, Alvarez 751 (IBUG).

Parmotrema perlatum (Huds.) Choisy, Bull. mens. Soc. linn. Lyon 21: 175, 1952.
= *Parmelia perlata* Huds., Meth. Lich., 216, 1803.

The marginal capitate soralia and cilia in the lobe margins are typical in this species; the medulla is K+ yellow (atranorin). It has been reported by Linder (1934) from Isla Socorro, by Imshaug (1956) from Mexico without precise locality and by Hale (1965), Dirzo (1985) and Gómez Peralta (1992) from Michoacán, D.F., Hidalgo, Puebla, San Luis Potosí and Veracruz.

Specimens examined. Region of Tlajomulco de Zuñiga, N slope of Cerro Viejo, Alvarez 686 (IBUG).

Pseudoparmelia crozalsiana (Lesd.) Hale, Phytologia 28: 189, 1974.
= *Parmelia crozalsiana* Lesd. ex Harmand, Lich. Fr. 4: 555, 1909.

The upper surface coarsely reticulately, soredia principally along the ridges, and the lower surface with a narrow marginal brown zone, are the principal features of this lichen; the cortex is K+ yellow and the medulla C-, KC-. Only known from D.F. and Veracruz (Hale, 1976).

Specimens examined. km 120, Guadalajara to Autlán road, El Mirador, Alvarez 620 (IBUG).

Punctelia subrudecta (Nyl.) Krog, Nord. J. Bot. 2: 291, 1982.
= *Parmelia subrudecta* Nyl., Flora, Jena 69: 320, 1886.

Thallus lightly reticulate with conspicuos white pores (pseudocyphellae) in the upper surface and with soredia granular and orbicular. Cortex K+ yellow; medulla K-, C+ red, KC+ red. Dávalos et al. (1972) reported this species from D.F. and Hidalgo; Bernabé (1977) from Guerrero and Castorena (1981) from Puebla.

Specimens examined. San Miguel El Alto to San Julián road, 20 km approximately SW of San Miguel El Alto, Alvarez 294 (IBUG).

Rimelia cetrata (Ach.) Hale & Fletcher, The Bryologist 93: 26, 1990.
= *Parmelia cetrata* Ach., Syn. Lich. 198, 1814.
= *Parmotrema cetrata* (Ach.) Hale, Phytologia 28: 335, 1974.
Fig. 5

Thallus foliose with cilia in the lobe margins, pycnidia numerous, apothecia with a central hole, soredia and isidia lacking. Cortex K+ yellow, C-; medulla K+ yellow-red. Bouly de Lesdain (1914, 1929) reported this species from D.F. and Michoacán, Imshaug (1956) without precise locality, Castorena (1981) from Puebla, Antonio (1985) from Guerrero and Gómez Peralta (1992) from Michoacán.

Specimens examined. Around Mazamitla town, Alvarez 197 (IBUG).

Rimelia reticulata (Tayl.) Hale & Fletcher, The Bryologist 93: 28, 1990.
= *Parmelia reticulata* Tayl. in Mark, Fl. Hibern. 148, 1836.
= *Parmotrema reticulatum* (Tayl.) Choisy, Bull. Mens. Soc. Linn. Lyon 21: 175, 1952.
Fig. 9

The upper cortex reticulate, cilia in the lobe margins and soralia laminal to submarginal defined this species. Cortex K+ yellow, C-; medulla K+ yellow-red, C-, KC+ red. Bouly de Lesdain (1929) reported it from Michoacán and Puebla, Gibert (1935) from D.F., Imshaug (1956) without precise locality, Hale (1969) from NE of Mexico, Coutiño and Mojica (1982, 1985) from Hidalgo and Veracruz, Dirzo (1985) from Guerrero and Gómez Peralta (1992) from Michoacán.

Specimens examined. Region of Tlajomulco de Zúñiga, Cerro Viejo, north slope, Alvarez 711 (IBUG). Nevado de Colima slopes, km 2-3 El Floripondio to Microwave Station road, Alvarez 575 (IBUG).

Rimelia subisidiosa (Mull. Arg.) Hale & Fletcher, The Bryologist 93: 29, 1990.
= *Parmotrema subisidiosa* (Mull. Arg.) Hale, Phytologia 28: 339, 1974.
= *Parmelia subisidiosa* (Mull. Arg.)Dodge, Ann. Mo. Bot. Garden 46: 87, 1959.

It is characterized by the upper surface densely isidiate and reticulate and the medulla K+ red. This species has been reported by Coutiño and Mojica (1982) from Hidalgo and Dirzo (1985) from Guerrero.

Specimens examined. Region of Mazamitla, Monteverde, Guzmán-Dávalos 4140 (IBUG).

PHYSCIACEAE

Heterodermia comosa (Eschw.) Follm. & Redon, Willdenowia 6: 446, 1972.
= *Anaptychia comosa* (Eschw.) Mass., Mem. Lichenogr. 39, 1853.

The main characteristic of this species is the numerous white cilia covering the upper surface of the narrow-spathulate lobes. Cortex and medulla K+ yellow. Bouly de Lesdain (1914) reported this species from Michoacán, Imshaug (1956) without precise locality, Kurokawa (1962) from Chiapas, D.F., Michoacán and Veracruz and Bernabé (1977) and Cortés (1988) from Guerrero.

Specimens examined. Region of San Sebastián del Oeste, km 11.5 La Estancia to Puerto Vallarta road, La Bulera, González Villarreal 3629 (IBUG). Sayula to Venustiano Carranza road, 3 km before La Cañada, Alvarez 781 (IBUG).

Heterodermia diademata (Tayl.) Awas., Geophytology 3: 113, 1973.
= *Anaptychia diademata* (Tayl.) Kurok., Beih. Nova Hedwigia 6: 28, 1962.

This lichen has a whitish gray thallus, lobes 0.5-1 mm wide, lower cortex light tan and apothecia up to 1.5 mm diameter, without or with a very short stipe and margin crenulate. Soredia and isidia absent. Cortex and medulla K+ yellow (zeorin). Kurokawa (1962) reported this species from Mexico from "Stat of Anna", Cortés (1988) from Guerrero and Gómez Peralta (1992) from Michoacán.

Specimens examined. km 6 La Manzanilla de la Paz to Mazamitla road, Trujillo 821-AA (IBUG).

Heterodermia echinata (Tayl.) W. Culb., Bryologist 69: 481, 1966.
= *Anaptychia echinata* (Tayl.) Kurok., Beih. Nova Hedwigia 6: 91, 1962.

It is defined by its thallus short fruticose, lobes narrow with the margin ciliate, lower surface white and fibrollose, without cortex, apothecia margin dissected and ciliate. It has been reported from D.F., Morelos and Oaxaca by Dávalos et al. (1972), from Oaxaca by Welden et al. (1979) and from Guerrero by Villanueva (1983) and Cortés (1988).

Specimens examined. Around Mazamitla town, Dueñas s.n., Oct. 12, 1989. (IBUG, XAL).

Heterodermia hypoleuca (Ach.) Trev., Atti Soc. ital. Sci. nat. 11: 615, 1868 (1869).
= *Parmelia speciosa* b. *hypoleuca* Ach. Syn. Lich.: 211, 1814.
Fig. 6

Thallus adnate, lower surface without cortex, white, with fruticose or irregularly branched rhizines, apothecia whith margin crenulate. Cortex and medulla K+ yellow (zeorin). Bouly de Lesdain (1914, 1929) reported this species from Puebla and D.F., Gibert (1935) from D.F., Imshaug (1956) without precise locality, Dávalos et al. (1972) from Durango, Michoacán and Hidalgo, Dirzo (1985) and Cortés (1988) from Guerrero and Gómez Peralta (1992) from Michoacán.

Specimens examined. km 6 La Manzanilla de la Paz to Mazamitla road, Trujillo 821-A (IBUG) and 844-C (IBUG).

FUNGI IMPERFECTI

Lepraria incana (L.) Ach., Lich. Suec. Prodr. 7, 1798.

Thallus whitish-green granular, more or less broad, growing on trees, and covering big zones. Only known from Michoacán (Gómez Peralta, 1992).

Specimens examined. Sayula to Venustiano Carranza road, 3 km before the La Cañada. Alvarez 774 (IBUG, XAL).

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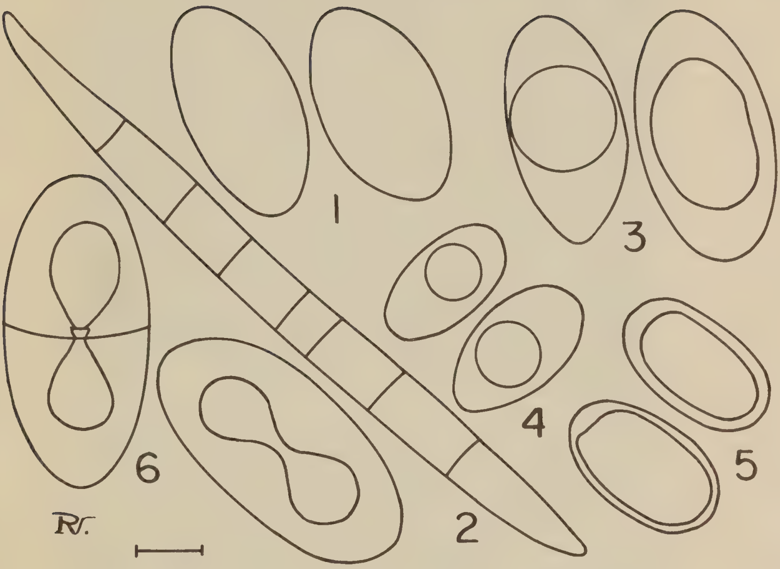
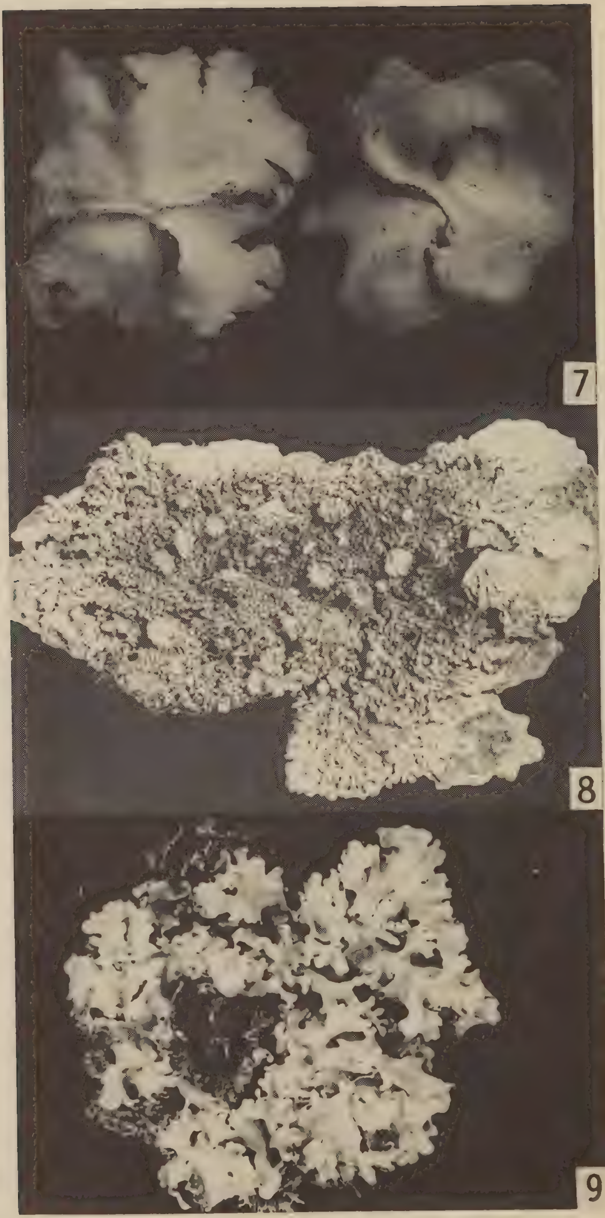


Figs. 1-6: Spores. 1: *Dermatocarpon miniatum* (Alvarez 106); 2: *Lobaria quercizans* (Guzmán-Dávalos 2949); 3: *Pannaria rubiginosa* (Alvarez 139); 4: *Cetraria fendleri* (Alvarez 119); 5: *Rimelia cetrata* (Alvarez 197); *Heterodermia hypoleuca* (Trujillo 844-C).



Figs. 7-9: Thallus. 7: *Dermatocarpon miniatum* (Gutiérrez, Jun. 27, 1989); 8: *Cetraria fendleri* (Alvarez 119); 9: *Rimelia reticulata* (Alvarez 575).

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NOTES ON BONDARZEWIA, HETEROBASIDION AND PLEUROGALA

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ABSTRACT - Latex production by *Bondarzewia mesenterica* is documented. Reportedly positive amyloid reactions of basidiospores of *Heterobasidion annosum* are refuted. Taxonomic implications of both observations are discussed. *Pleurogala gen. nov.* is proposed for *Lactarius* sect. *Panuoidei*.

KEY WORDS: *Bondarzewia*, *Lactarius*, *Heterobasidion*, *Pleurogala*, Russulaceae, Bondarzewiaceae, Polyporaceae.

INTRODUCTION

Bondarzewia Singer (1940) has attracted the attention of taxonomists for many years. Singer proposed the originally monotypic genus for *Ceriporus montanus* Quélet based upon its coarsely ornamented, strongly amyloid spores which were unusual among polyporoid species (see transmission and scanning electron micrographs by Besson 1970, Keller 1979, and Pegler & Young 1972). The correct name for *Bondarzewia montana* (Quél.) Singer, the type species, is now *B. mesenterica* (Schaeff.) Kreisel (1984). Two additional species were recognized by

Bondarzew & Singer (1941): *B. talpae* (Cooke) Bond. & Singer (later excluded from *Bondarzewia* as *Meripilus talpae* (Cooke) Reid by Pegler & Young (1972)) and *B. berkeleyi* (Fr.) Bond. & Singer. Only one other species is known in the genus: *B. guaitecasensis* (Henn.) Wright apud Singer (1963) [syn. *B. perniciosa* Singer, 1953]. All 3 species fruit at the bases of living trees from a subterranean sclerotium-like stipe attachment to roots or butts which are white-rotted (Bondarzew 1970, Domanski et al. 1973, Ferry 1897, Gilbertson & Ryvarden 1986, Long 1913, Nuss 1986, Overholts 1953, Singer 1953, Wright & Deschamps 1972).

BONDARZEWIACEAE

Kotlaba & Pouzar (1957) established the family Bondarzewiaceae for Aphyllophorales with amyloid, ornamented spores and included two other genera, *Amylaria* Corner and *Hericium* Pers. Subsequently *Hericium* and *Amylaria* were transferred to the Hericiaceae (Donk 1964) and Amylariaceae (Corner 1970), respectively. Pegler & Young (1972) analyzed the spore morphology and hyphal structure in *Amylaria*, *Bondarzewia*, and *Hericium*, and concluded that the Bondarzewiaceae should be restricted to the type genus, *Bondarzewia*. Singer (1975) accepted the family as such, placing it in the Agaricales because of a perceived alliance to *Lactarius* (Russulaceae). In support of his position, Singer cited the macroscopic similarity of *B. guaitecasensis* to a hydnangiaceous genus, *Hybogaster* Singer, which exudes white latex as does *Lactarius*. Jülich (1981) recognized a distinct order, the Bondarzewiales, for Bondarzewiaceae, Amylariaceae, and a new family, the Hybogasteraceae, with a single genus *Hybogaster*. He treated *Hericium* in the Hericiaceae, Hericiales.

Stalpers (1979) listed perceived similarities between *Heterobasidion* Bref. and *Bondarzewia*: amyloid, ornamented basidiospores, clamp connections absent in basidiomes but present (sometimes rarely) in cultures, the presence of a *Spiniger*-like anamorph in both genera, parasitism and the production of a white rot, and laccase production. Partly as a consequence of these similarities, Stalpers reduced both the Echinodontiaceae and the Amylariaceae to synonymy with the Bondarzewiaceae, including *Amylaria*, *Bondarzewia*, *Echinodontium* Ellis & Everh., *Heterobasidion*, *Laurilia* Pouzar and *Wrightoporia* Pouzar in the family.

Addressing the reasoning behind Stalpers' proposed classification, Singer (1984) specifically refuted Stalpers' assertion that the basidiospores of *Heterobasidion* were amyloid. However, Gluchoff-Fiasson et al. (1983) reinforced the taxonomic linkage of *Heterobasidion* to *Bondarzewia* by the discovery in both of pseudocystidia in the hymenia and peculiarly branched sulfo-aldehyde positive oleiferous hyphae in cultures. Stearyl-velutinal was identified as the sesquiterpene giving the sulfo-aldehyde reaction common between the genera. According to Gluchoff-Fiasson et al. (1983) stearyl-velutinal was originally isolated from *Lactarius velutinus* Bert. Additional linkages of the Bondarzewiaceae to the Russulaceae (*Russula* and *Lactarius*) were provided by Frank (1986) who reported macrochemical similarities between *B. mesenterica* and several *Russula* species.

Singer (1984) noted the presence of skeletoid hyphae and a non-mycorrhizal parasitic habit in an unusual species, *Lactarius igapoensis* Singer, which he suggested helped to link *Bondarzewia* with *Lactarius* section *Panuoidei* Singer. He claimed the two genera were not very closely allied to each other but simultaneously argued for classification in the same order, the Agaricales, based on gross similarities.

LATEX AND LACTIFEROUS HYPHAE

In his description of the family Bondarzewiaceae, Singer (1975 p. 785) stated, "often lactescent with a white, milk-like, often abundant latex when bruised.....conducting elements (at least some species) present, even numerous in the form of laticiferous hyphae.....lacteocystidia (extensions of the laticiferous ducts in the hymenial layer) often numerous." Singer provided no documentation for these observations which stood in direct contradiction to the statement by Pegler & Young (1972 p. 53) regarding *B. mesenterica* (as *B. montana*) and *B. berkeleyi*: "Neither gloeo-vessels nor conducting elements have been observed in either species." Similarly, Donk (1964) in part segregated the Hericiaceae from the Bondarzewiaceae by the apparent lack of gloeocystidia in *Bondarzewia*, although seven years later, he recognized gloeoplerous hyphae and latex production in *Bondarzewia* (Donk 1971). All of these contradictions have contributed to an element of uncertainty clouding taxonomic questions surrounding *Bondarzewia*.

Neither the specific *Bondarzewia* descriptions cited above nor contemporary technical descriptions of *Bondarzewia mesenterica* (mostly as *B. montana*), *B. berkeleyi* and *B. guaitecasensis* mention latex production (Bondarzew 1971, Domanski et al. 1973, Gilbertson & Ryvarden 1986, Jahn 1979, Ji-Ding & Xiao-Qing 1992, Martin & Gilbertson 1978, Murrill 1907, Overholts 1953, Ryvarden 1976, Tylutki 1987, Wright & Deschamps 1972). However, lactiferous hyphal systems have been well documented and illustrated for both *B. berkeleyi* and *B. mesenterica* (Corner 1984, Gluchoff-Fiasson & Kühner 1982, Gluchoff-Fiasson et al. 1983, Kühner 1980, Reijnders & Stalpers 1992), and pseudocystidia (mucronate ends of lactiferous hyphae) have even been reported and illustrated for both species (Gluchoff-Fiasson et al. 1983). Furthermore, Singer (1984) reports the presence of a white acrid latex and lactiferous hyphae in *B. guaitecasensis*, and as mentioned by Donk (1971), 112 years ago Peck (1881) noted copious milky juice exuded when a basidiome of *B. berkeleyi* was cut, leading him to propose the name *Polyporus lactifluus* Peck for the "new species". Historically this observation became buried, probably because Murrill (1904 p. 338) unfortunately attached little significance to Peck's observation in his treatment under the generic name *Grifola*: "It seems different from *G. Berkeleyi* only in having milky juice, a character possessed by other members of this genus and probably present in *G. Berkeleyi* in its young stage." Murrill (1907) later placed *P. lactifluus* in synonymy with *G. berkeleyi* without mentioning latex.

OBSERVATIONS

BONDARZEWIA:

In 1992 under ideal fruiting conditions (fog and rain) we obtained a fresh terrestrial basidiome of *B. mesenterica* rooting in a needle bed under *Abies procera* Rehd. (Larch Mt., Oregon, Nov. 4, 1992, coll. S. Redhead 7323, L.L. Norvell, G.T. Norvell & P.W. Trimm, DAOM 216094) and discovered that it too produces latex. Latex had been observed years earlier at least once before in *B. mesenterica* by D.E. Stuntz and J.F. Ammirati when examining unretained teaching materials. In 1993, Prof. Ammirati recalled that the latex was exuded where the tube layer attached to the sterile context. Latex production in our 1992 collection was restricted to the pore layer and immediately adjacent tissues. White, acrid, nonchanging latex was freely exuded when this layer was repeatedly cut with a razor blade. The thick context of the basidiomes did not bleed. After harvesting, the basidiome was maintained in a fresh condition outdoors in rainy weather for more than 24 hours and still produced latex. Microscopic examination of the basidiome confirmed the presence of extensive, weakly sulfo-vanillin-positive lactiferous hyphae (2.5-5.0 μm diam.) in the hymenophoral trama, and also pseudocystidia as seen by Gluchoff-Fiasson et al. (1983).

HETEROBASIDION:

Basidiospores of *Heterobasidion annosum*, like those of many species with long lived basidiomes, can accumulate in sufficiently large numbers on the pileus surface to cake it. Individual basidiospores of both *H. annosum* (DAOM 147634) and *H. insulare* (Murr.) Ryv. (DAOM 145670 & 166580), when viewed microscopically, even using oil immersion, do not exhibit amyloid reactions, although the asperulate natures of the spores are readily apparent. Deposits on pileus surfaces of *H. annosum* (DAOM 170830) provided more than enough spores to test amyloidy of masses when scraped off. When viewed both macroscopically on a slide and microscopically in Melzer's reagent, piled masses of spores do not exhibit any increased bluing or blackening. What was noted was a faint bluish tinge around some refractive ornamentation and the apiculus on some spores. However, these same bluish tints were visible when the spores were mounted in straight chloral hydrate solution lacking any iodine. The coloration was very faint and was interpreted by us as resulting from refraction of light and not a chemical complex involving iodine.

DISCUSSION

LATEX IN *BONDARZEWIA*:

With the discovery of latex in the last of the three known species of *Bondarzewia*, it can now be stated that latex production is a consistent generic feature, as is an acrid taste. Failure to note latex by others may have been a result of drying weather or other less than ideal conditions. Old or drying basidiomes of *Lactarius*, which are less long lived, often fail to exude latex. It is also possible that the characteristic may not have been checked by taxonomists, as latex production is not a normal feature among polypores. The fact that the lactiferous hyphae are restricted to the hymenophoral trama helps explain the apparent absence of lactifers noted by Pegler & Young (1972) who only described tissues from the mid-context in detail.

BASIDIOSPORES IN *HETEROBASIDION:*

Stalpers (1979 p. 415) stated, "when a spore print of a specimen (made directly on an objective glass) is examined in Melzer's reagent, a number of spores always show a blue colour. As the amyloid reaction is only distinct in a minority of spores and is probably confined to the ornamentation, it is not amazing that this reaction has escaped detection." Other authors specifically report nonamyloid spores (Corner 1989, Gilbertson & Ryvarden 1986, Ryvarden 1976) and Jülich (1981) emphatically noted the basidiospores were "completely" nonamyloid. As noted by us above, this report of amyloidy of *Heterobasidion* basidiospores appears to have been based on refraction of fine ornamentation and the apicular region. Gluchoff-Fiasson et al. (1983) mistakenly cited Keller (1973) as reporting amyloid spores in *H. annosum*. In fact Keller merely reported ornamentation on the spores which was best viewed in Melzer's reagent under the light microscope - "En regardant attentivement les spores de *H. annosum* dans le réactif de Melzer, nous avons eu l'impression que ces dernières étaient pourvues d'une surface bosselée, bien qu'elles soient toujours qualifiées de lisses dans la littérature. Comme l'observation normale ne permet pas un examen sûr, nous avons utilsé le microscope électronique pour vérifier notre hypothèse." Unfortunately the erroneous report of amyloidy became compounded when Korhonen (1987 p. 305) listed amyloid asperulate basidiospores as one of "two prominent characters in the genus" *Heterobasidion*, apparently based on the publication by Gluchoff-Fiasson et al. (1983).

In view of our findings, and in the absence of convincing documentation to the contrary, we conclude that *Heterobasidion* always has nonamyloid basidiospores.

PHYLOGENY:

As indicated above, several competing hypothetical linkages have been proposed by basidiomycete taxonomists in attempts to classify *Bondarzewia* at the familial and ordinal levels. On the one hand, the genus (and family when restricted to the genus) has been placed in the Agaricales (Singer 1975, 1986; Frank 1986). On the other, linkages to the Aphyllophorales have been argued (Stalpers 1979; Gluchoff-Fiasson et al. 1983; Reijnders & Stalpers 1992). Although Stalpers' (1979) case is considerably weakened by the presence of nonamyloid spores in *Heterobasidion*, his comparison is not without merit, especially in light of further observations on biochemistry and/or anatomy by Gluchoff-Fiasson & Kühner

(1982), Gluchoff-Fiasson et al. (1983) and Reijnders & Stalpers (1992).

The Agaricales as circumscribed by Singer (1986) is considered to be polyphyletic (Redhead 1988). If one accepts that the Agaricales sensu Singer (1986) are polyphyletic, it becomes reasonable to accept the order Russulales independent of the Agaricales sensu stricto (as have Smith 1971, Kühner 1980, Jülich 1981, Watling 1982, Thiers 1984, Miller & Watling 1987) and to allow for the possibility that the Russulales evolved independently of the Agaricales from the Aphyllophorales. Such a scenario could explain linkages among *Bondarzewia*, the Russulaceae, and aphyllophoraceous families with either lactiferous hyphal systems, amyloid ornamented spores, or both. Reijnders & Stalpers (1992) have also concluded *Bondarzewia* has linkages to both the Russulaceae and the Aphyllophorales. Although currently we include the Bondarzewiaceae, Auriscalpiaceae and Russulaceae in the Russulales, we agree with Donk (1971 p. 407) that the Bondarzewiaceae "belongs to the largely uncharted division where the Russulales, the clavarioid genus *Amylaria*, and perhaps also the Hericiaceae, Auriscalpiaceae, and still other groups belong." Inferred monophyletic familial or ordinal relationships among the Russulaceae, Bondarzewiaceae, and families in the Aphyllophorales offer ideal hypotheses to be tested using recent molecular techniques. Current technology is needed to chart these murky waters.

NEW GENUS

When the Russulales is viewed as an independently evolving taxon, originating from the Aphyllophorales and culminating in some cases in astrogastraceous genera, generic and familial concepts within the order require re-examination. *Lactarius* section *Panuoidei* (see Dennis 1970, Pegler & Fiard 1979, Pegler 1983, Singer 1952, 1984) - the section exhibiting features most similar to *Bondarzewia* - represents a phylogenetic relict within the Russulaceae. Unlike virtually all other species of *Russula* and *Lactarius*, species in this section are parasites of living woody tissue and not mycorrhizal (Singer 1984). They have pleurotoid basidiomes, poorly developed sphaerocyst bearing tissue, and a tendency to produce a subiculum with skeletoid hyphae, as does *Lactariopsis* Henn. (Heim 1937). Within the Russulaceae, we envisage a lineage proceeding from plesiomorphic saprophytic or parasitic *Lactarius*-like species through possibly several sections of the mycorrhizal genus *Lactarius* to the genus *Russula* - which is probably a paraphyletic group - by derived characters: the loss of latex production and increased sphaerocyst production (see Watling & Nicoll 1980). We accept the arguments that the astrogastraceous genera are end lines (Smith 1971, Heim 1971, Thiers 1984) which we assume evolved several times from both *Lactarius* and *Russula*. *Lactarius* section *Panuoidei* is sufficiently morphologically and biologically distinct to represent a separate genus. The removal of this lignicolous, avelate and pleurotoid section from *Lactarius* and the recognition of *Lactariopsis* as an independent lignicolous, velate genus (as was accepted by Heim 1937, 1971) makes *Lactarius* more homogeneous: the remaining well known species are all either mycorrhizal or suspected of being mycorrhizal (Trappe 1962) as well as centrally to only slightly eccentrically stipitate. Recognition of at least three lactescent lamellate genera in the Russulaceae should facilitate phylogenetic analysis.

PLEUROGALA (RUSSULACEAE)

Pleurogala* gen., *stat. et nom. nov.

≡ *Lactarius* section *Panuoidei* Singer, Kew Bull. 7: 301 (Latin diagnosis). 1952. *Typus*: *Lactarius panuoides* Singer

Basidiomes pleurotoid (flabelliform to spathulate), either laterally attached or with a strongly eccentric short stipe, white to yellowish brown. Latex white to whitish, unchanging, acrid or mild. Basidiospores white in mass, ellipsoid to subglobose, with amyloid spinose to reticulate ornamentation. Pseudocystidia present in hymenium. Lacking clamp connections. Sphaerocysts poorly to well developed. Pileipellis a turf of erect hair-like to fusoid or ventricose cells.

Fruiting directly on woody tissues, living trunks, creeping rootlets, with or without a subiculum of thick-walled hyphae.

Known from: Japan, Brasil, Trinidad and Guadeloupe.

***Pleurogala panuoides* (Singer) comb. nov.**
≡ *Lactarius panuoides* Singer, Kew Bull. 7: 300-301. 1952.

***Pleurogala uyedae* (Singer) comb. nov.**
≡ *Lactarius uyedae* Singer, Nova Hedw. 40: 436-438. 1984.

***Pleurogala campinensis* (Singer) comb. nov.**
≡ *Lactarius campinensis* Singer, Nova Hedw. 40: 438-441. 1984.

***Pleurogala igapoensis* (Singer) comb. nov.**
≡ *Lactarius igapoensis* Singer, Nova Hedw. 40: 441-445. 1984.

KEY TO SPECIES: see Singer 1984: 436.

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A EUROPEAN SPECIES OF THE LICHEN GENUS INGADERIA AND COMMENTS ON THE RELATIONSHIP OF THE GENERA DARBISHIRELLA AND INGADERIA (ROCCELLACEAE)[1]

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Abstract: *Ingaderia troglodytica* Feige & Lumbsch from the Mediterranean region is described as new to science. It represents the first member of that genus to be discovered outside the neotropics. The relationship of the genera *Darbishirella* and *Ingaderia* is discussed and *Darbishirella* is reduced to synonymy with the latter. The new combination *Ingaderia gracillima* (Krempelh.) Feige & Lumbsch is made.

While studying the lichen flora of the Balearic archipelago, one of us (GBF with the help of his son Sebastian) found a peculiar fruticose lichen resembling the neotropical *Darbishirella gracillima* in morphology. This lichen was collected at Cala Morell on Minorca. The same plant had previously been collected by Poelt on the island of Sardinia but at that time was misdeterminedas *Gorgadesia mira* Tavares by Feige (NIMIS & POELT 1987). In the meantime we received further specimens from colleagues who collected this lichen in other parts of the western Mediterranean region. Further study showed it to be an undescribed taxon related to the neotropical genera *Darbishirella* and *Ingaderia*. The new species is described below.

While preparing the description of the new species, it became evident that the generic position of the lichen was somewhat unclear. The distinction of the two monotypic genera *Darbishirella* and *Ingaderia* from the neotropics was therefore reexamined. The results of this study are also presented below.

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[1] This manuscript is dedicated to Professor emer. Dr. O.H. Volk (Würzburg) on the occasion of his 90th birthday.

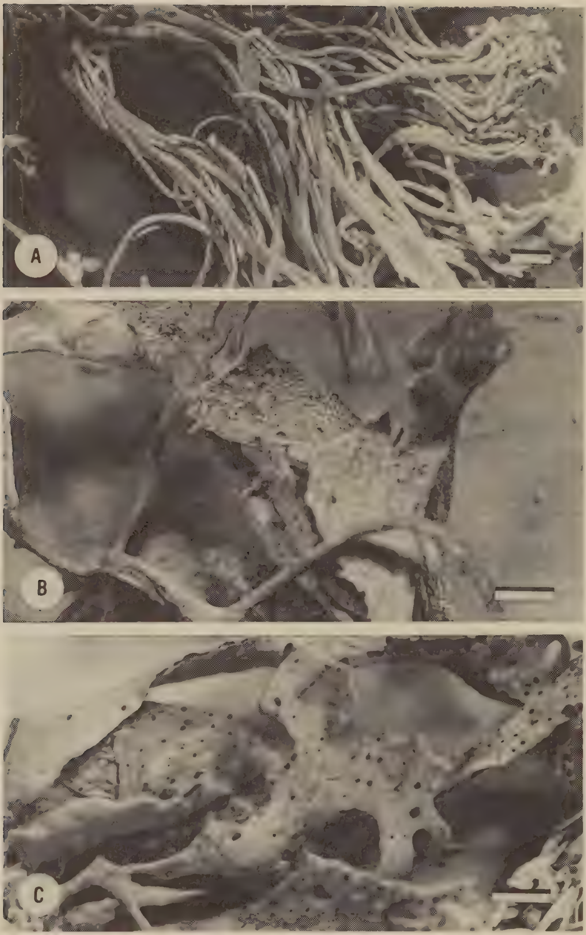

Fig. 1. Morphology of *Ingaderia troglodytica*, part of the holotype (ESS). A. Thin terminal branches, B. & C. Flattened main branches (note dark fruiting bodies of a undetermined lichenicolous fungus in C) (Scale = 1 mm).

Material and Methods

Material. Specimens were studied from the following herbaria: ESS, GZU, M, MUB, S and the private herbaria of S. Huneck (Halle) and H.T. Lumbsch (Essen).

Methods. *Microscopy*. Thalli were cut using a freezing microtome in 16-20 μm thickness and stained with lactophenol cottonblue.

Chemistry. The chemical constituents were identified using thin layer chromatography, TLC (CULBERSON 1972, CULBERSON et al. 1981, CULBERSON & JOHNSON 1982) and high performance liquid chromatography, HPLC, according to Feige et al. (1993).

The new species

Ingaderia troglodytica Feige & Lumbsch, spec. nov.

(Fig. 1)

Planta saxicola. Thallus fruticosus, uniformis, viridulo-griseus vel albido-griseus, pendulus vel suberectus, albido-grisei pruinosus, ramosus; rami primati applanati, superficierum reticulati, ca. 2-3.5 x 0.1-1.2 cm; rami terminales cylindricei, ca. 0.1-0.2 mm in diametro. Cortex usque ad 35 μm crassus, hyalinus, hyphis periclinalis. Medulla luteola, inconspicua, coalescens. Stratum algarum discontinuum. Alga ad genus *Trentepohlia* pertinens. Soredia et isidia nulla. Ascomata et pycnidia incognita.
Thallus acidum gyrophoricum, lecanorinum et orsellinum continens.

Typus: Spain, Baleares, Minorca, Cala Morell, benaeth prehistoric caves (Coves Troglodytes), NW vertical calcareous cliffs, 3.10.1991, *G.B. & S. Feige* (ESS-11058 - holotype, KOELN, MUB - isotypes, further isotypes will be distributed in Vezda, Lich. rar. exs. 64).

Thallus saxicolous, fruticose, greenish grey to whitish grey, pendant to suberect, whitish grey pruinose, branched; main branches prominent, flat, with a reticulate surface, ca. 2-3.5 x 0.1-1.2 cm; terminal branches terete, ca. 0.1-0.2 mm in diam. Cortex with periclinally arranged hyphae, hyaline, up to 35 μm thick. Medulla yellowish, inconspicuous, coalescent, sometimes not distinguishable from the cortex (=*Darbishirella* type). Algal layer discontinuous. Photobiont belonging to the genus *Trentepohlia*. Soredia or isidia absent. Ascomata or pycnidia not seen.

Chemistry: Gyrophoric (major), lecanoric (minor) and orsellinic (trace) acids by HPLC and TLC.

Morphologically this new species resembles a poorly developed *Roccella* species, but it can readily be distinguished by the presence of gyrophoric acid and the different anatomy of the thalli. It grows on exposed miocene calcareous cliffs on Minorca in coastal areas. The species occurs mainly in small caves in the rock in somewhat shady places. Associated species at the type locality include *Dirina massilensis* Durieu & Montagne, *Lecanactis grumulosa* Fr., *Opegrapha durieui* Montagne and *Roccella phycopsis* (Ach.) Ach.

Further specimens examined: **Italy**, Sardinia, Prov. Sassari, Capo Caccia, 50 m alt., 23.7.1985, *P.L. Nimis & J. Poelt* (GZU). - Sicily, Isole Pelagie, Lampedusa - Punta occidentale dell' Isola, tra Punta Parise, Capo Ponente e C. Teresa, 80-100 m alt., 13.4.1992, *J. Poelt* (ESS-11690, GZU). - **Spain**, Almeria, Carboneras, Punta Los Muertos, 100 m alt., 18.3.1990, *J.E. Egea & Alonso* (MUB-21308). - **Morocco**, Al-Hoceima, Playa del Hotel Quemado I., 0-30 m alt., 11.4.1990, *J.E. Egea & Alonso* (MUB-21305), Carreterra de la costa a 5 km al W., 11.4.1990, *J.E. Egea & Alonso* (MUB-21304). - Ras-el-Mara, Cab de l'eau, 30 m alt., 12.4.1990, *J.E. Egea & Alonso* (MUB-21307).

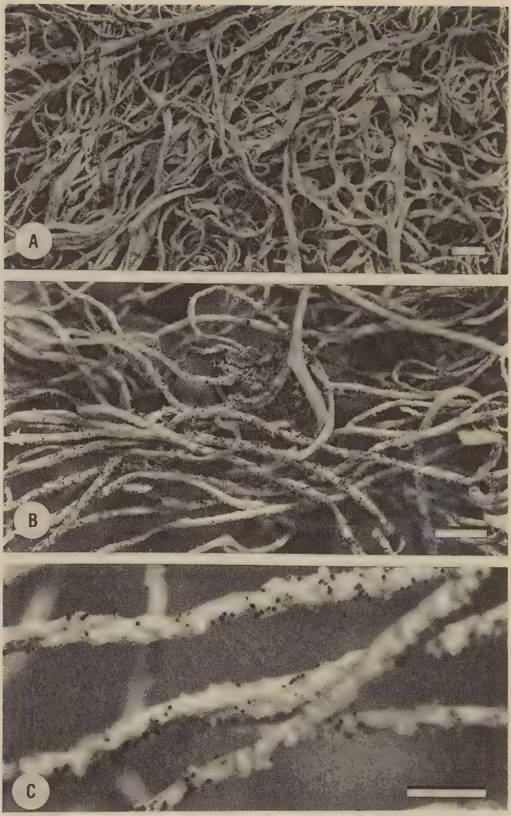

Fig. 2. Morphology of *Ingaderia gracillima* and *I. pulcherrima*. A *I. gracillima* (Tehler 2351, S) B & C *I. pulcherrima* (COLO exs. 558, M) (Scale: A & B =1mm; C = 0.5 mm).

The generic concept

The phylogeny and generic concepts of the Roccellaceae were recently discussed in detail by TEHLER (1990). A description of the genera *Darbishirella* and *Ingaderia* is given there. *Darbishirella* and *Ingaderia* s.str. are distinguished by their morphology and chemistry (Tab. 1). While *Darbishirella* has flat main branches (Fig. 2 A) and contains a despidone chemosyndrome based on psoromic acid, *Ingaderia pulcherrima* contains depsides and has thin main branches (Figs. 2 B & C). TEHLER (1990) has previously mentioned that these genera are very similar especially in their thallus anatomy. However, since the genus *Ingaderia* is only known in the sterile condition it was excluded from the cladistic analyses.

Tab. 1. Comparison of *Ingaderia troglodytica* with *I. (Darbishirella) gracillima* and *I. pulcherrima.*

Species	Morphology	Anatomy	Chemistry	Substrate	Distribution
Ingaderia gracillima (=*Darbishirella gracillima*)	Flat and reticulated main branches, heavily pruinose. Terminal branchlets terete, entire.	*Darbishirella* type	Psoromic 2'-*O*-demethylpsoromic acids and unknowns	Saxicolous or corticolous	Chile, Peru
Ingaderia pulcherrima	Main branches thin, occasionally reticulated, pruinose. Terminal branchlets terete with blackish papillae.	*Darbishirella* type	Erythrin, lecanoric and orsellinic acids	Saxicolous or corticolous	Chile
Ingaderia troglodytica	Flat and reticulated main branches, heavily pruinose. Terminal branchlets terete, entire.	*Darbishirella* type	Gyrophoric, lecanoric and orsellinic acids and unknowns	Saxicolous	Western Mediterranean

Ingaderia troglodytica exhibits characters of both the monotypic genera *Darbishirella* and *Ingaderia*. This new species has the morphology of *Darbishirella*, but contains depsides, closely related to those present in *Ingaderia pulcherrima*. All three species share the same type of thallus anatomy, which is called here *Darbishirella* type, characterized by a discontinous algal layer.

With the discovery of *Ingaderia troglodytica* the distinction of the genera *Darbishirella* and *Ingaderia* on the basis of the thallus morphology and chemistry, cannot be continued. We consider all three species to be congeneric and thus *Darbishirella* becomes a synonym of *Ingaderia*. The following new combination is necessary:

Ingaderia gracillima (Krempelh.) Feige & Lumbsch, comb. nov.
Bas.: *Roccella gracillima* Krempelh., Verh. Zool.-Bot. Ges. Wien 26: 442 (1877).
Syn.: *Dictyographa gracillima* (Krempelh.) Darb., Ber. Dtsch. Bot. Ges. 15: 6 (1897), nom. illeg. - *Darbishirella gracillima* (Krempelh.) Zahlbr. ex Darb., Bibl. Bot. 9 (45): 13 (1898).

The distribution of the genus *Ingaderia* is quite remarkable being disjunct between western South America and the western Mediterranean. At the moment we cannot interprete this kind of distribution, but it definitely seems to be a relict. A thorough search for this genus should be made in the mediterranean regions of North America. The present distribution might be close to that of *Haematomma subpuniceum* (Müll Arg.) B. de Lesd. (LUMBSCH et al. 1993) which exhibits to the well known western North America western Europe disjunct (KÄRNEFELT 1980) with range extension to South America.

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DISTINGUISHING CHARACTERISTICS OF SELECTED *PHOMA* SPECIES

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ABSTRACT

The fungal form-genus *Phoma* is discussed with regard to taxonomy and criteria for speciation. A key for identification is included. The published literature on *Phoma* is scattered and fragmentary. This paper consolidates information from a variety of sources, and includes species not discussed by Sutton (1980). Mycologists, plant pathologists, quarantine authorities and future monographists should find this paper useful.

CRITERIA FOR SPECIATION

Saccardo's differentiating criteria for *Phoma*, *Phyllosticta*, and *Ascochyta* are as follows: *Phoma* and *Phyllosticta* producing 1-celled conidia and occurring on stems and leaves respectively; *Ascochyta* with 2-celled conidia and found on leaves only. This criterion was critically discussed by Dennis (1946), who considered the traditional separation of pycnidial fungi based on whether they are collected on stems or leaves as irrational. In addition, generic distinctions based on the presence or absence of a septum conidia of this group of fungi were not considered valid. Wollenweber and Hochapfel (1936) had difficulties distinguishing between the form-genera *Phoma* and *Ascochyta*. This problem was solved by Brewer and Boerema (1965), and Boerema (1970) when they examined a number of species of both the genera in detail. In *Ascochyta*, the septation of conidia (distoseptation) appeared to be an essential part of conidial development while any septation of conidia (euseptation) in *Phoma* species was considered as a secondary process, not connected with conidiogenesis. This implied that the genuine *Ascochyta* both *in vitro* and *in vivo* mainly produces 2-or more celled conidia, whereas *Phoma* species in culture form mainly 1-celled conidia, although *in vivo* conidia were often 2-celled (Boerema, 1970; and Zherbele, 1971). Therefore, some species classified by Wollenweber and Hochapfel (1936) as *Ascochyta* have been treated under "form-genus" *Phoma* (Boerema and Dorenbosch, 1973).

The distinction between *Phoma* and *Phyllosticta* has been a matter of controversy. Allescher (1901) adopted a strict rule that *Phyllosticta* occurs on leaves (except those of conifers) while *Phoma* occurs on any other part of the plant. This view is erroneous as many species of *Phyllosticta* have been found on different parts of the plants or other substratum, whereas *Phoma* species have been reported ubiquitously on leaves, stems, roots, water, in the air, soil and even on animals. Grove (1935) stated that the distinction between *Phoma* and *Phyllosticta* was biological. *Phyllosticta* was usually a parasite (holoparasite) while *Phoma* was saprophyte or facultative parasite. Therefore, *Phyllosticta* was mostly confined to "spots" which it killed. This view is also incorrect as the bulk of the literature indicates that *Phoma* and *Phyllosticta* are both parasites as well as saprophytes. The precise differentiation can be made on the basis of spores and conidiogenesis. Spores of *Phyllosticta* are usually larger than those of *Phoma*, and most *Phyllosticta* spores have a slimy appendage and a watery sheath around them. *Phoma* spores do not have a sheath and appendage. However, some *Phyllosticta* species do not have the appendage, either. Conidiogenous cells of *Phyllosticta* are cylindrical or lageniform rather than ampulliform like those of *Phoma* species (Van der Aa, 1973; Yip, 1989).

The importance of host for specificity for the taxonomy of *Phoma* species has been overestimated. The assumption that each host genus or species is colonized by specialized *Phoma* species caused many investigators to ignore morphological characters when distinguishing *Phoma*, species. A morphological species may attack or survive on several host plants. It should be possible to identify a *Phoma* species when it is not possible to identify the host, e.g. when floral parts are lacking or when the fungus is cultured on artificial media. Morphological characteristics must be studied *in vitro* in order to establish a more realistic and practical classification of *Phoma* and *Phoma*-like fungi. In pure culture, a large number of fungi previously assigned to several species actually represent a restricted number of morphological types. Examples are

Phoma exigua Desm. (Boerema and Howeler, 1967; Van der Aa and Van Kesteren, 1971) and *Phoma macrostoma* Mont. (Boerema and Dorenbosch, 1970), which are known to develop widely on different hosts. Boerema (1969) stated that a new form species must be identifiable without the knowledge of substrate. This is possible in *Phoma* and *Phoma*-like fungi, if the morphology of pycnidia and conidia are considered with all other characters observable *in vitro* for species differentiation (habit, colony growth, crystal formation, pigmentation, and chlamydospores, etc.).

Many new species have been described from India: (Tandon and Bilgrami, 1960; Pavgi and Singh, 1966; Hasija, 1970; Bilgrami, 1963; Agarwal and Sahni, 1964; Dutta and Ghosh, 1965; Chandra and Tandon, 1965, 1966; Pavgi and Sharma, 1971; Shreemali, 1972,1973, 1978; Jamaluddin *et al.*, 1975; Maiti *et al.*, 1978; Rai and Misra, 1981; Agrawal and Misra, 1981). Rai (1981) studied the Indian species of *Phoma*, and on the basis of morphological and cultural characters he formed 20 broad morphological groups (Rai, 1985, 1986a, 1986b, 1987; Rai and Rajak, 1982a, 1982b, 1983a, 1983b, 1985, 1986a, 1986b; Rajak and Rai, 1982a, 1982b, 1983a, 1983b, 1984a, 1984b, 1984c; and Rai *et al.*, 1985). These groups include *P. medicaginis* Malbr. and Roum. var.*pinodella* (L.K. Jones) Boerema, *P. medicaginis* var. *medicaginis* Malbr. and Roum., *P. pomorum* Thum. *P. herbarum* Westend., *P. exigua* var. *exigua* Desm., *P. tropica* Schneider and Boerema, *P. glomerata* (Corda) Wollenweber and Hochapfel, *P. sorghina* (Sacc.) Boerema, *P. multirostrata* (Mathur *et al.*) Dorenbosch and Boerema, *P. capitulum* Pawar *et al.*, *P. betae* Frank, *P. jolyana* Pirozynski and Morgan-Jones, *P. fimeti* Brun., *P. chrysanthemicola* Hollos., *P. complanata* (Tode ex Fr.) Desm., *P. destructiva* Plowr, *P. eupyrena* Sacc. and *P. arachidicola* Marasas *et al.*

Conidial ontogeny is one of the important criteria for genera and species differentiation. In *Phoma*, conidia are produced by small parent cells inside pycnidia. Each parent cell can produce a series of conidia. Consequently, each new conidium takes the place of older cells. (Ciccarone and Russo, 1969). The first conidium develops from a papilla at the top of the parent cell (Sutton and Sandhu, 1969; and Ciccarone and Russo, 1969). Boerema and Bollen (1975) have described conidial development in detail. The process is culminated by the formation of a separation plate between the parent cell and the conidium. Some dissolved wall material remains surrounding the conidium, comprising a mucilaginous mass. A collarette is left on the parent cell when the conidium secedes. In some species, the conidia become 2-celled by an ingrowth from the lateral wall, which apparently from the beginning attains the thickness of the final septum. A pore remains in the center of the septum which is associated with Woronin bodies and membrane-bound plugs.The conidia swell during germination. A new electron transparent layer can be distinguished inside the conidial wall that is continuous with the germ-tube which emerges through the ruptured outer wall of the conidium (Boerema and Bollen, 1975).

MORPHOLOGY AND CULTURAL CHARACTERS

Pycnidia and conidia of many *Phoma* species are morphologically similar. However, detailed studies indicate that "form-species" can be based on clear, stable and generally recognizable morphological and cultural characteristics (Boerema, 1970; Van der Aa, 1973; Singh, 1974; and Rai, 1981).

Rai (1981) reported that growth and colour of the colony helps in differentiating the species in the genus *Phoma*. Slow growth of *P. fimeti* under various physical and nutritional conditions clearly differentiates it from the other species. Production of pigments and metabolites in the mycelium as well as in the medium has often been found to be a useful differentiating character in certain species of *Phoma*. *P. macrostoma* var. *macrostoma* was separated from *P. macrostoma* var. *incolorata* on the basis of formation of red-violet pigment in the mycelium of the former, which turns bluish with sodium hydroxide (Boerema and Dorenbosch, 1973). Rajak and Rai (1983d) reported that *P. macrostoma* var. *macrostoma* developed red pigmented mycelium on all the media, except, Coon's, Czapek's, and Richard's media. The pigment formation was favoured by 15-23°C and pH 4, 8, and 11. All the nitrogen sources, except urea, and only sucrose as the carbon source supported the formation of pigmented mycelium.

According to Dorenbosch (1970), the dark-yellow to greyish colony of *P. glomerata* turns tea-brown when a drop of strong solution of NaOH is added. Rai (1981) reported that *P. glomerata*, when subjected to different physical and nutritional conditions, developed colonies of different shades which on application of NaOH solution became dark-yellow or dark-green.

In *P. exigua* var. *exigua* the greenish (pigment α.) discolouration of the agar media on application of a drop of NaOH is an important diagnostic character.

It is an oxidation reaction of metabolite "E" (Boerema and Howeler, 1967; Logan and Khan, 1969; Logan and O' Neill, 1970; Rai, 1981, and Rajak and Rai, 1982). This greenish colour (pigment a) gradually becomes reddish (pigment β). The positive oxidation reaction test of metabolite 'E' was exhibited by *P. exigua* var. *exigua* on malt-agar, oat-agar, Brown's agar, Richard's agar and Asthatna and Hawker's media (Rai, 1981; Rajak and Rai, 1983a) at 20-23°C and pH 6-7, while at pH 3 and 4 the yellow colour appeared on addition of NaOH. According to Boerema and Dorenbosch (1973), *P. betae* may also exhibit some oxidation reaction like *P. exigua var. exigua*. This characteristic was observed when *P. betae* was grown on Czapek's medium (Rajak and Rai, 1983a), on D-glucose, and at a temperature range of 20-23°C only (Rai, 1981). Reddish discolouration of the medium below the colony, which changes to violet blue on addition of NaOH in the case of *P. herbarum*, has been recognized as one of the important diagnostic characters.

Dorenbosch (1970) reported that with *P. chrysanthemicola* grown on oat-agar and malt-agar, a yellowish-red or orange-red discolouration of the medium has been observed but on application of NaOH the red colour fades. Rai (1981) found that *P. chrysanthemicola* caused yellow discolouration of the medium when grown on Brown's and Richard's medium, but caused an orange-red colour at 23°C and when the nitrogen sources were ammonium nitrate, ammonium chloride, and ammonium sulphate. Fading of colour was reported when a drop of NaOH was added, but the phenomenon could not be produced when the carbon sources were maltose and citric acid.

In *P. fimeti* yellow dicolouration of the medium which is one of the important diagnostic characters, was reported when the temperature was 20-23°C, pH 6-7, with carbon sources glucose and glycine and ammonium chloride as nitrogen sources. The colour does not change on addition of NaOH (Rai, 1981).

According to Rai (1981), *P. jolyana* did not exhibit olive-buff to amber discolouration of the medium as reported by Boerema *et al.* (1977). Interestingly, many species of *Phoma*, viz., *P. tropica*, *P. glomerata*, *P. eupyrena*, and *P. arachidicola*, which have not been known for pigment production, exhibited this character when subjected to different physical and nutritional conditions. In *P. sorghina* the formation of a red mycelial mat and reddish discolouration of the medium was constant and unaffected by different factors (Rai, 1981). Although pigment production is a slightly variable character it may still have importance as a taxonomic character when combined with other characters (Rai, 1981).

Shape and size of pycnidia have been considered as important taxonomic characters in many genera of Sphaeropsidales, including *Phoma*. Pawar *et al.* (1967) erected *P. capitulum*, *P. ostiolata*,, and *P. ostiolata* var. *brunnea* on the basis of slight differences in the shape and size of pycnidia. Shreemali (1978) created two new species of *Phoma*, viz. *P. jatrophae* and *P. variosporae* based on superficial morphological differences. Rai and Misra (1981) established a new species *P. usthrina* which has been distinguished from *P. capitulum* on the basis of size and shape of pycnidia. Similarly, Agrawal and Misra (1981) described a new species *P. lucknowensis* from alkaline soils which resembles *P. eupyrena* in all characters, except the size of pycnidia. According to Singh (1974) shape and size of pycnidia in *P. exigua* were highly variable characters under different cultural conditions. Boerema and Dorenbosch (1968) examined the newly created species of *Phoma* of Pawar *et al.* (1967) and reported that the differences in pycnidial shape and size are not stable and impracticable for use in species or varietal delimitation. They accepted only one species, *P. capitulum*, as valid. Rai (1981) reported that shape and size of pycnidia were highly variable and significantly affected by different nutrient media, temperature, pH, carbon and nitrogen sources. However, *P. sorghina*, *P. fimeti* and *P. eupyrena* did not exhibit any remarkable variation in the size of pycnidia when grown at different hydrogen-ion concentrations.

The nature and thickness of pycnidial walls have often been considered as diagnostic criteria in Sphaeropsidales. Kranz (1963) separated *Phoma foveata* from *P.exigua* on the basis of the pycnidial wall being prosenchymatous in the former and pseudoparenchymatous in the latter. Van der Aa (1973) in his taxonomic studies on *Phyllosticta* used thickness and thinness of the pycnidial wall for differentiating species. Rai (1981) reported that the nature of pycnidial walls in almost all the species of *Phoma* was constant and unaffected by changing conditions.

The use of ostiole of the pycnidia has long been neglected in species differentiation in Sphaeropsidales as a taxonomic character since it is highly affected by substratum and other growth conditions. Clements and Shear (1931) also criticized the use of ostioles in species differentiation owing to their plasticity. Rai (1981) found that in some of the species of *Phoma*, the ostiole was constantly present, while in other species the ostioles developed under one set of growth conditions but was absent under other growth conditions. It can be argued that the ostiole can be considered in support of other characters for species differentiation in *Phoma*. Many species of *Phoma* developed a neck in pycnidia when grown in pure culture. Boerema and Dorenbosch (1968), Singh (1974), and Rai (1981) opined that neck is a variable character and should not be used in differentiating the species of *Phoma*. Traditionally, a great emphasis has been laid on the shape and size of spores in differentiating species of many fungi. Many investigators took advantage of existing superficial differences in the conidia size for erecting new species (Shreemali, 1978; Rai and Misra, 1981; and Agrawal and Misra, 1981). On the other hand, Singh (1974) reported many variations in the size of conidia of *Phoma exigua* under different cultural conditions. Rai (1981) reported that the size of conidia in all the 18 species and 5 varieties of *Phoma* was highly variable, being greatly affected by various factors. Singh (1974) observed that conidial shape of *P. exigua* was much affected by the temperature and different nitrogen sources. Variation in the shape of conidia was also observed in all the 18 species and 5 varieties of *Phoma* (Rai, 1981), but the variation was limited. Guttulation and septation in conidia have also been found to be variable characters (Rai, 1981).

The use of chlamydospores and dictyochlamydospores as taxonomic characters have been recognized by Nickersen and Mankowski, (1953). Dorenbosch (1970), and Boerema and Dorenbosch (1973) and Boerema *et al.* (1977) have emphasized the use of chlamydospores and dictyochlamydospores in delimiting many species of *Phoma*. Thus, *P. medicaginis* var. *pinodella* was distinguished from *P. medicaginis* var. *medicaginis* on the basis of abundant production of chlamydospores in the former (Boerema, 1967; Rai, 1981). Formation of *Alternaria*-like dictyochlamydospores in *P. glomerata*, and 1-celled chlamydospores and dictyochlamydospores in *P. pomorum* are the characteristic features of these species (Boerema and Dorenbosch, 1973). According to Dorenbosch (1970) formation of typical small chlamydospores singly or in chains in *P. eupyrena* is its diagnostic character while *P. chrysanthemicola* develops dark-brown to black structures that look like pseudosclerotial masses and consist of chlamydospores. Similarly, in *P. sorghina*, *P. jolyana* (Boerema *et al.*, 1977) and *P. arachidicola* (Marasas *et* *al.*, 1974) the importance of chlamydospores and dictyochlamydospores as identifying characters have been realized. Rai (1981) confirmed that the formation of chlamydospores and dictyochlamydospores should be taken into account for identification in species of *Phoma* as these characters are not affected by different physical and nutritional conditions. Thus, the use of chlamydospores and dictyochlamydospores as criteria in *Phoma* appears to be justified as indicated by the work of Boerema *et al.* (1965-1977).

A KEY TO THE IDENTIFICATION OF PHOMA SPECIES

Rajak and Rai (1985) presented a key to the identification of species of *Phoma* in pure culture. After detailed morphological and cultural studies they found that all the morphological characters should be taken into account for the differentiation of species of *Phoma*.

KEY

1a. Colonies generally colourless or whitish 2
2b. Colonies coloured and of different shades 4

2a. Conidia 1-celled ...3a
2b. Conidia 3-celled ...3b

3a. Pycnidia pseudoparenchymatous, conidia 1-celled, 3.2-5.6 X 2-3.2 µm in dia. ....*P. capitulum*
3b. Pycnidia massive, parenchymatous, conidia 1-to 3-celled, highly guttulated, 3-11 X 2-3.5 µm ....*P. complanata*
4a. Pycnidia pseudoparenchymatous ...5
4b. Pycnidia parenchymatous ...12
5a. Chlamydospores produced ...6
5b. Chlamydospores not produced ...9
6a. Colonies pale to dark-green, orange-red to yellow discolouration of the medium, formation of dark-brown to black, irregular, pseudosclerotial massess, conidia 3-6.6 X 2-3.7 µm in dia. ...*P. chrysanthemicola*
6b. Chlamydospores and dictyochlamydospores produced singly or in chains ...7
7a. Colonies pink to red with compact aerial mycelium reddish discolouration of the medium, production of needle-like crystals, chlamydospores in chains, dictyo-chlamydospores 2-3-celled, 7-15 um in dia. ...*P. sorghina*

7b. Colonies brown to grey or greyish-green ...8

8a. Colonies brown to grey, chlamydospores single or in chains, thick-walled, dark-brown, 1-celled or divided ...*P. arachidicola*

8b. Colonies greyish-green, chlamydospores in chains, 1-celled, greyish-black ...*P. destructiva*

9a. NaOH test positive ...10

9b. NaOH test negative ...11

10a. Colonies dull-green, pycnidia abundant, covered with tuft of hairy hyphae, conidia broad 3.8-8.9 X 2.5-5 µm, red pigment produced which on application of NaOH change green then to red. ...*P. betae*

10b. Colonies greyish-green with masive mycelium, red pigment produced which on application of NaOH turns blue. ...*P. herbarum*

11a. Colonies olivaceous-green, fast-growing, with much aerial mycelium, conidia bi-guttulate, 2.2-5.8 X 1.5-2.3 um ...*P. tropica*

11b. Colonies slow growing, yellow discolouration of the medium takes place, conidia 1-celled, 2.8-5.1 X 1.9-3 µm ...*P. fimeti*

12a. Chlamydospores not produced ...13

12b. Chlamydospores and dictyochlamydospores produced ...17

13a. NaOH test positive, colonies greyish black with scalloped margins, production of red pigments which on application of NaOH turns green and finally to red. ...*P. exigua* var. *exigua*

13b. NaOH test negative ...14

14a. Conidia 1-celled ...15

14b. Conidia 1 to 4-celled ...16

15a. Colonies flat, greyish-black, with little or no aerial mycelium, pycnidia abundant, rosy-buff, conidial slime produced, conidia 5.6-7.4 X 2.7-3.7 µm ...*P. multirostrata*

15b. Colonies flat, light-grey, with little aerial mycelium, pycnidia in radial rows, ostiolate, 80-155 µm in dia. ...*P. medicaginis* var. *medicaginis*

16. Colonies dense, greyish-black, pycnidia ostiolate, ostiole broad, conidia 3-10 X 1.5-4 µm ...*P. macrostoma*

a. Red pigmented hyphae ...*P. macrostoma* var. *macrostoma*

b. Pigment in mycelium absent ...*P. macrostoma* var. *incolorata*

17a. Only chlamydospores formed ...18

17b. Chlamydospores and dictyochlamydospores both formed ...19

18a. Chlamydospores smallest in size, abundant, in chains ...*P. eupyrena*

18b. Chlamydospores bigger, highly guttulated ...*P. medicaginis* var. *pinodella*

19a. No discolouration of the medium ...20

19b. Amber discolouration of the medium takes place, dictyochlamydospores produced terminally then become lateral, 1-8 transversely septate, 13-50 X 7-23 µm, colonies without sectors ...*P. jolyana*

19c. On application of NaOH medium turns tea-brown on malt-agar, dictyochlamydospores *Alternaria*-like rosy-buff exudation of conidial slime ...*P. glomerata*

20. Dictyochlamydospores *Stemphylium*-like and terminal ...*P. pomorum*

VARIOUS SPECIES OF *PHOMA*

1. *P. arachidicola* Marasas *et al.*, in *Phytophylactica* *6*: 195-202, 1974; *Res. Bull. Coll. Agri. Expt.* *56*: 1-137, 1969; *Rhodesia agric. J.* *59*:199-201, 1962; *Can. J. Bot.* *47*:745-749, 1969.

Colony characteristics:

Colonies grey to dull-yellow, closely appressed at the margin, attaining a diameter of 5-5.5 cm on oat-agar in 14-days; pycnidia dark-brown, abundant, globose to sub-globose to flask-shaped, pseudoparenchymatous, ostiolate, 100-250 µm; conidia hyaline, 1-celled, mostly ovoid, few ellipsoid, ends obtuse, 4.8-8 X 2.5-3.9 um; chlamydospores produced after 2-weeks, single or in groups, dark-brown, 2 to 3-celled, globose to sub-globose, thick-walled, 7-15 µm.

Production of chlamydospores single or in groups is a typical character of the present fungus.

2. *P. betae* Frank, in *Ned. Kruidk. Archf*.II.,*2*:181,1877; *Hedwigia* *24*:74, 1885; *Bull. Soc. Mycol. Fr.* *7*:19, 1891; *Z. Rubenzuckerind* *42*:904-906, 1892: *Studies in Mycology* *3*: 22-23, 1973.

Cultural characteristics:

Colonies greenish-grey to black, attaining similar diameter on oat-agar and malt-agar in 7-days; pycnidia black, abundant, globose to sub-globose, pseudoparenchymatous, ostiolate, 74-150 um; Conidia hyaline, 1-celled, mostly ovoid on rice-agar and malt-agar, ellipsoid on oat-agar, relatively broader, 4-7

X 3.2-4 µm; chlamydospores in chains, grey, relatively larger celled.

The present species is characterized by relatively broad conidia (Boerema and Dorenbosch, 1973).

3. *P. capitulum* Pawar *et al.*, in *Trans. Br. Mycol. Soc.* *50*:261, 263, 1967, *Trans. Br. Mycol. Soc*. *51*: 145-169, 1968.

Cultural characteristics:

Colonies with cottony aerial mycelium, oval, attaining a diameter of 5 cm on oat-agar in 7-days; pycnidia dull-yellow to dark-brown, abundant, globose to sub-globose, some coalesce to form irregular fructifications, pseudoparenchymatous, ostiolate, 78-179 µm; conidia hyaline, 1-celled, ovoid to ellipsoid, ends obtuse, 3.5-5.2 X 2-3.1 µm.

Cottony colony, with abundant pseudoparenchymatous and ostiolate pycnidia are diagnostic characters of this fungus.

4. *P. chrysanthemicola* Hollows, in *Annls. Hist. Nat. Mus. Natn. Hung*. *5*:456, 1907; *Can. J. Pl. Sci.* *38*: 469, 1958; *Pl. Path.* *12*:21, 1963; *Persoonia* *6(1)*; 1-14, 1970; *Phytopath. Z.* *83*:239-243, 1975; *Curr. Sci*.*2*: 216, 1953.

Colony characteristics:

Colonies dark-grey with compact aerial mycelium, attaining a dia. of 3-3.5 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, compound parenchymatous, ostiolate, 88-250 µm; conidia hyaline, 1-celled, mostly ovoid on rice-agar and malt-agar, ellipsoid on oat-agar, 4-7.3 X 2.5-3.4 µm; orange-red discolouration of the medium appears.

An important diagnostic character of this fungus is the occurrence of dark-brown to black pseudosclerotial, irregular massess (Dorenbosch, 1970).

5. *P. complanata* (Tode ex Fr.) Desm., in *Annls. Sci. Nat*. (Bot.) (III)16:299-300, 1851; *Trans. Br. Mycol. Soc.* *67(2)*:, 289-319, 1976.

Cultural characteristics:

Colonies cottony with much aerial mycelium, attaining a dia. of 6.7 cm on oat-agar in 7-days; pycnidia thick-walled dark-yellow to black, globose, parenchymatous, 74-150 µm; conidia hyaline, 1-2-celled, 3.9-11 X 2- 3.2 µm.

A typical character of the present fungus is massive character of the mature pycnidia (Boerema, 1976).

6. *P. destructiva* Plowr, in *Gard. Chron. N.S. 16*: 620, 1881; *J. Agricult. Res. 4*: 1-20, 1915; *Z. Parasitkde 8*:592, 1971, *Studies in Mycology 3*:24-25, 1973.

Cultural characteristics:

Colonies dark-green with much aerial mycelium, attaining a dia. of 5-6 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, pseudoparenchymatous, ostiolate, 78-155 µm; conidia hyaline, 1-celled, mostly ellipsoid on oat-agar, ovoid on rice-agar and malt-agar, 4.5-7.5 X 3.2-3.5 µm; chlamydospores in chains, single-celled, grey, non-guttulated or less guttulated.

7. *P. eupyrena* Sacc. in *Michelia 1(5)*: 525, 1879; *Trans. Br. Mycol. Soc.* 29:30, 31, 1946; *Persoonia 6*, (1), 1-4, 1970; *Sylloge Fungorum 3*:127, 1884; *Mycotaxon 31* (2) :427-434, 1988.

Cultural characteristics:

Colonies green with compact aerial mycelium, attaining a dia. of 4.2-4.8 cm on oat-agar in 7-days; pycnidia abundant, black, globose to sub-globose, parenchymatous, 74-160 µm; conidia hyaline, 1-celled, mostly ellipsoid, few ovoid, guttulated, 3.7-6.2 X 2-3.5 µm; typical, small, black chlamydospores produced in chains.

Production of typical and small chlamydospores in chains is a stable character of this species (Dorenbosch, 1970). The chlamydospores of the present fungus differ from *P. medicaginis* var. *pinodella* in their size. The former are relatively small in size and less guttulated.

8. *P. exigua* var. *exigua*, in *Annls. Sci. Nat. (Bot) 8*: 34, 1847 and III, *11*: 282, 283, 1849; *Atti. Soc. Crittogam. Ital 3*: 67, 1881; *Sylloge Fung. 3*:133, 1884; *Bull. Soc. Mycol. Fr. 6*: 179, 1890; *Trans. Br. Mycol. Soc. 67* (2) 289-319, 1976; *Persoonia 5*: (1): 15-28, 1967 *Persoonia 6 (1)*:1-14, 1970; *Mycotaxon 32*: 477-490, 1988.

Cultural characteristics:

Colonies grey to black with irregularly scalloped margins, attaining a diameter of 6-7 cm on oat-agar in 7-days; pycnidia black, abundant, sub-globose to globose, some coalesce to form irregular fructifications, parenchymatous, ostiolate, 79-296 µm; conidia hyaline, 1 to 2-celled, ovoid on malt-agar and rice-agar, ellipsoid on oat-agar, 3.7-11.1 X 2-3.7 µm.

The greenish-blue discolouration of the agar-media on application of a drop of NaOH is an important diagnostic character. This greenish colour gradually becomes reddish.

9. P. exigua var. inoxidabilis Boerema and Veig

Cultural characteristics:

Colonies black with irregularly scalloped margins, attaining a dia. of 7 cm on oat-agar in 7-days; pycnidia black, abundant, globose to sub-globose to flask-shaped, some coalesce to form irregular pycnidia, parenchymatous, ostiolate 67-286 µm; conidia hyaline, 1-celled, mostly ellipsoid, few ovoid, 3.9-7.4 X 2.5-3.5 µm; no pigments produced.

10. P. fimeti Brun., in Bull. Soc. Bot. Fr. 36 (II, 11): 338, 1889; Icon 1803-1806; Persoonia 6:(1) 1-14, 1970; Z. Parasitkde 8: 579-581, 1936; Studies in Mycology 3:1, 4-5, 20, 29-30, 1973.

Cultural characteristics:

Colonies ashy to green with compact aerial mycelium, attaining a dia. of 1.7-3 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, pseudoparenchymatous, ostiolate, 74-160 µm; conidia hyaline, 1-celled, mostly ovoid, few ellipsoid, ends obtuse, 2.9-5.2 X 2-3.2 µm; yellow discolouration of the medium on malt-agar appears.

The species can be easily identified due to its very slow rate of growth.

11. P. glomerata (Corda) Wollenw. & Hochapf., in Z. Parasitkde 8:592, 1936;Icon 4:39, 1840; Syll. 3:175-176, 197, 1884; Hedwigia' 23: 109, 1884 Hedwigia 36: 157, 1897; N. Amer. Fungi 391,1859; Mycol. Zbl. 2:244-297, 326, 1913; Persoonia 4:52-59, 1965;Persoonia 6 (1):1-14, 1970; Kew Bull. 31(3):533-544, 1977; Studies in Mycology 3(1):11-12, 14, 22, 30-32, 1973.

Cultural characteristics:

Colonies dull-dark-yellow, flat with little aerial mycelium, in sectors, some with woolly aerial mycelium, others with pycnidial types, attaining a diameter of 4.5-7 cm on oat-agar in 7-days; pycnidia dark-yellow to black, abundantly produced, in concentric rings, globose to sub-globose, some cylindrical, parenchymatous, ostiolate, 74-160 µm; Conidia hyaline, 1-celled, mostly ellipsoid, some ovoid, 4-8.3 X 2.5-3.8 µm; on application of strong solution of NaOH the medium turns to tea-brown; chlamydospores and dictyochlamydospores produced. Dictyochlamydospores are *Alternaria*-like and in chains.

12. *P. herbarum* Westend., in *Bull. Acad. R. Belg. Cl. Sci.* *19(3)*:118, 1852; *Trans. Br. Mycol. Soc.* *29:* 33-35, 1946; *44*:578-582, 1961; *Persoonia* *3*:9-16, 1964; *Mycotaxon* *33*:81-90, 1988.

Colony characteristics:

Colonies grey to green, massive mycelial mat (mycelial-type), uniform rate of growth, attaining a diameter of 4-5 cm in 7-days on malt-agar and oat-agar, in sectors; pycnidia grey to black, sub-globose to globose, flask-like, usually parenchymatous, sometimes with short neck, ostiolate, 74-150 μm; Conidia hyaline, 1-celled, mostly ovoid on malt-agar, ellipsoid on oat-agar, 3.7-8.1 X 2-3.2 μm; red pigments produced, which on application of NaOH, change to blue.

Sometimes pycnidial-type strains of *P. herbarum* also occur, characterized by the production of abundant pycnidia and sparse mycelium. This creates confusion with *P. glomerata*. The latter can be differentiated from the former by the presence of chlamydospores and dictyochlamydospores.

At the 8th International Botanical Congress at Paris (1954) this species was selected as the type species of the "form-genus" *Phoma* (Boerema, 1964, 1970).

13. *P. jolyana* Pirozynski and Morgan-Jones, in *Trans. Br. Mycol. Soc.* *51*:200, 1968 (II):*Persoonia* *4*(1):47-68, 1965; *Kew Bull.* *31(3)*:533-544, 1977; *Mycotaxon* *30:* 239-246,1987.

Cultural characteristics:

Colonies greyish-black, attaining a diameter of 4-5 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, compound, parenchymatous, ostiolate, 88-290 μm; conidia hyaline, 1-celled, ellipsoid on oat-agar ovoid on rice-agar and malt-agar, few kidney-shaped, 3.7-8.5 X 2-3.8 μm; chlamydospores and dictyochlamydospores in chains, abundantly produced on malt-agar, multicellular and laterally arranged.

A typical character of this species is chlamydospores in chains and lateral arrangement of dictyochlamydospores.

14. *P. macrostoma* var. *macrostoma* Mont., in *J. Bot.* London, *58*:240, 1920:*Annls. Sci. Nat*. (Bot.) III, *11*:52, 1849; *Persoonia* *6(1):* 49-58, 1970; *Meded. Plziektenk.* *142*: 138-142, 1965; *Studies in Mycology* *3*:8, 1973; *Mycotaxon* *20 (1)*:197-204, 1984.

Cultural characteristics:

Colonies pinkish-red with much aerial mycelium, attaining a dia. of 7-7.5 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, pyriform, parenchymatous, ostiolate, (ostiole upto 48 µm wide), 80-200 µm; conidia hyaline, 1-celled, some 2-celled or 3-celled, mostly ellipsoid, few ovoid, few kidney-shaped, 7.5-14.2 X 2.5-3.7 µm.

The present variety of macrostoma can be easily distinguished from another variety, viz., incolorata by absence of reddish-pigments in the hyphae (Boerema and Dorenbosch, 1970).

The original spelling macrostomum is now treated as an orthographic error and altered in macrostoma (Boerema and Dorenbosch, 1970).

15. P. macrostoma var. incolorata (Horne.) Boerema and Dorenbosch, in J. Bot. London. 58: 240-241, 1920; Michelia 2: 341, 1881; Hedwigia (Dresden) 23: 109, 1884; Trans. Br. Mycol. Soc. 10:104, 1924; Persoonia 6(1):47-58, 1970; Studies in Mycology 3:17, 1973.

Cultural characteristics:

Colonies black, attaining a dia. of 7-7.5 cm on oat-agar in 7-days; pycnidia greyish-black, globose sub-globose, parenchymatous, ostiolate, 110-210 µm; conidia hyaline, 1-celled to 2-celled, mostly ellipsoid, few ovoid, 4-11.9 X 2-3.5 µm; reddish pigments absent in hyphae.

The variety of P. macrostoma can be differentiated with variety macrostoma of the same species by absence of red pigments (Boerema and Dorenbosch, 1970).

16. P. medicaginis Malbr. and Roum. var. pinodella (L.K.Jones) Boerema, in Bull. N. Y. St. Agric. Exp. Sta. 547: 10, 1927; Neth. J. Pl. Path. 71:88, 1965; Mycotaxon 28(1):241-248, 1987.

Cultural characteristics:

Colonies grey to black, flat, attaining a dia. of 5-6.2 cm on oat-agar in 7-days; pycnidia grey to black, scattered, some in radial rows, globose to sub-globose, parenchymatous, 80 -175 µm; conidia hyaline, 1-celled, mostly ellipsoid, few ovoid, 4-8.7 X 2.5-3.3 µm; chlamydospores abundantly produced, grey to black, in chains, globose to sub-globose, highly guttulated.

Formation of crystals on malt-agar is one of the characteristic features of this fungus. The production of these crystals differ from strain to strain. These can only be produced after some weeks of growth. Another important and stable character of this species is production of chlamydospores.

17. *P. medicaginis* var. *medicaginis* Malbr. and Roum., in *Fungi gall. Exs. Cent.* *37*: 3675, 1886; *Revue Mycol.* *8*: 91, 1886; *Mycotaxon* *29*: 477-487, 1987.

Cultural characteristics:

Colonies buff, flat, attaining a dia. of 4-4.8 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, parenchymatous, ostiolate, 85-215 µm; conidia hyaline, 1-celled, mostly ellipsoid, some ovoid, 3.7-9.6 X 2-2.5 µm.

This variety can be distinguished from *P. medicaginis* var. *pinodella* by different growth pattern, absence of chlamydospores and few crystals scattered, and only in cultures over 1-month old.

18. *P. multirostrata* (Mathur *et al.*) Dorenbosch and Boerema, in *Sydowia* *13*: 1959; *Curr. Sci.* *31*: 566, 1965; *Mycopath. Mycol. Appl.* *29*: 86, 275-276, 1966, *34*: 93, 1968; *Mycotaxon* *33*: 339-351, 1988.

Cultural characteristics:

Colonies grey to black, flat with little aerial mycelial mat, attainig a dia. of 7-7.2 cm on oat-agar in 7-days; pycnidia in concentric rings, abundant, globose to sub-globose, parenchymatous, ostiolate, sometimes 1 to 2 ostioles in a pycnidium 80-160 µm; conidia hyaline, 1-celled, ovoid on malt-agar and rice-agar ellipsoid on oat-agar with obtuse ends, sometimes one end acute and other end obtuse, guttulated 4-7.2 X 2.2-3.1 µm; rosy-buff conidial slime produced.

The pycnidia of this fungus are typically parenchymatous and ostiolate, which seems to be stable and diagnostic character of this species.

19. *P. pomorum* Thum., in *Z. parasitkde* *8*:595-597, 1936: *Fungi pomicoli* 105, 1879 (III); *CMI Descr. Path. Fungi. Bact.* 135; *Kew Bull.* *31(3)*: 1977; *Studies in Mycology* *3*: 37, 1973.

Cultural characteristics:

Colonies greyish-black, with much aerial mycelium, attaining a dia. of 6-6.5 cm on oat-agar in 7-days; pycnidia black, globose to sub-globose, coalesce to form irregular fructifications with many ostioles, parenchymatous, 73-225 µm; conidia hyaline, 1-celled, mostly ovoid, few ellipsoid, ends obtuse 4-7.4 X 2-3.7 µm; abundant production of single-celled chlamydospores in chains in combinations with dictyochlamydospores.

It can be distinguished from P. glomerata especially by its possession of chains of single chlamydospores as well as dictyochlamydospores.

20. P. sorghina (Sacc.) Boerema, Doren. and V. Kest. comb.-nov., in Persoonia 7: 134, 1973, (IV); Kew Bull. 31(3): 1977.

Cultural characteristics:

Colonies pink with much aerial mycelium, attaining a diameter of 5.5-7.2 cm on oat-agar in 7-days; pycnidia grey, globose, sub-globose to flask-shaped, pseudoparenchymatous, ostiolate, 75-155 µm; conidia hyaline, 1- celled, mostly ellipsoid, few ovoid 3.9-7.1 x 2-2.7 µm; yellow discolouration of the medium in acidic condition below the colony; chlamydospores abundant, in chains, mostly globose.

A typical diagnostic character of this species is production of chlamydospores and dictyochlamydospores in chains, and red pigment in hyphae.

21. P. tropica Schneider and Boerema, in Phytopath. Z. 83: 360-366, 1975.

Cultural characteristics:

Colonies olivaceous to greasy with much aerial mycelium, attaining a dia. of 4.5-6.2 cm on oat-agar in 7-days; pycnidia dark-brown, globose, sub-globose to flask-shaped, some coalesce to form irregular fruiting bodies, pseudoparenchymatous, ostiolate, 88-300 µm; conidia hyaline, 1-celled, mostly ellipsoid, some ovoid, 3.5-6.8 X 2.2-2.6 µm.

The pycnidia of this fungus are typically flask-like, pseudoparenchymatous and ostiolate.

In addition to the above mentioned species of Phoma, Sutton (1980) listed the following 10-species:

P. cava Schulz., P. dennisii Boerema nom. nov., P. epicoccina Punithalingam, Tulloch & Leach, P. hedericola (Dur. & Mont.) Boerema, P. leveillei Boerema and Bollen nom. nov., P. lingam (Tode ex Schw) Desm., P. lycopersici Cke, P. nebulosa (Pers. ex S.F. Gray) Berk., P. putaminum Speg., P. tracheiphila (Petri) Kantachveli & Gikachvili. P. cava, P. dennisi, P. hedericola, P. lingam, P. lycopersici, P. nebulosa, P. putaminum and P. tracheiphila has been discussed in detail by Dorenbosch (1970), Holliday and Punithalingam (1970), Punithalingam and Holliday (1972), Boerema and Dorenbosch (1973), Boerema and Bollen (1975), Boerema (1976), and Morgan-Jones and Burch (1988).

Some other species of Phoma

1. *P. americana* Morgan-Jones & White, in *Mycotaxon 16 (2)*: 403-413, 1983.

Cultural characteristics:

Colonies olivaceous, with sparse aerial mycelium, particularly in a wide marginal zone on malt-agar, attaining a diameter of 9 mm at 20°C after 4 days, centre darker and thinly floccose or in part slightly ropy, reverse olivaceous;pycnidia abundant, sub-globose to flask-shaped, brown to blackish-brown, partly immersed or superficial, pseudoparenchymatous, bearing long, unbranched, flexuous, appendage-like, 1-1.5 µm wide hyphae which are sometimes slightly swollen at their tips with one or more ostioles (up to four), usually bearing one or more short necks, 100-220 µm, where confluent the pcnidial mass can reach up to 850 µm; conidia hyaline, (occasionally one-septate), cylindrical or narrowly ellipsoidal, biguttulate, obtuse at both ends, 5-7 X 2-2.5 µm; exudation of salmon colour; chlamydospores very variable, intercalary or terminal, solitary or in chains, sub-globose, ellipsoidal or irregular, uni-, bi-, or multicellular, when septate, phragmosporous or dictyosporous, thick-walled, non-septate chlamydospores, 15-18 µm.

P. americana is easily distinguished from other species, including *P. pomorum*, by its chlamydospores, relatively thick-walled pycnidia, and its slow growth on malt-agar.

2. *P. hoehnelii* Van Kest. var. *hoehnelii* and var. *urticae* in *Trans. Br. Mycol. Soc. 67 (2)*: 289-319, 1976.

Cultural characteristics:

Colonies slow-growing with greyish mycelial mats, yellowish or brownish discolouration below the colony, attaining a diameter of 2.5-3.5 cm on oat-agar in 7 days; pycnidia mostly small, upon addition of iodine the cell-walls of the pycnidia become red; conidia hyaline, 1-celled, 3.5-5 X 1-1.5 µm.

Both varieties are slow-growing with greyish mycelial mats. But var. *urticae* soon becomes sterile whereas var. *hoehnelii* shows mostly abundant production of pycnidia. Ageing cultures often produce a pinkish discolouration of the medium.

3. *P. hoehnelii* subsp. *amplior* (Sacc. & Roum.) Boerema & van Kesteren comb. nov.

Colony characteristics:

Colonies greyish with buff tings, attaining a dia. of 3-4 cm on oat-agar in 7-days; pycnidia abundant, relatively large, pseudosclerenchymatous; conidia hyaline, 1-celled, 4-6 X 1.5-2.5 µm; salmon or saffron discolouration of the medium takes place.

4. P. proboscis Heiny, in Mycotaxon 36(2):457-471, 1990; Ecology and Epidemiology 81(8): 905-909, 1991.

Cultural characteristics:

Colonies lanose or somewhat floccose, dark-brown to dark olivaceous, attaining a diameter of 3.4 cm on oat-agar in 7 days at 20°C; pycnidia solitary or confluent, sub-globose to flask-shaped, brown to blackish brown, partly immersed or superficial, mostly glabrous, pseudoparenchymatous, with one or more ostioles (up to nine), usually developing one or more elongate necks, which sometimes branch. Pycnidia 173-550 X 112-275 µm, with neck length 1/3 to 3 times the diameter of the pycnidium. Conidia salmon color in mass, hyaline, eguttulate, cylindrical or narrowly ellipsoidal, occasionally one-septate, 5.5-15.0 X 2.3-5.0 µm, averaging 10.5 X 3.5 µm. Cllamydospores spherical, unicellular, intercalary, approximately 14 um in diameter.

P. proboscis differs from other species in having rostrate pycnidia, relatively large eguttulate conidia that are occasionally septate, unicellular, spherical chlamydospores, and an optimum growth rate at cooler temperatures (20°C).

5. P. urticola van der Aa & Boerema sp. nov., in Trans. Br. Mycol. Soc. 67(2):289-319, 1976.

Colony characteristics:

Colonies with fluffy whitish and twisted aerial mycelium, producing discoloration in the light to saffron-salmon, attaining a diameter of 5.5-6.5 cm on oat-agar in 7-days; pycnidia at initial stage scattered later followed by development of perithecia, pycnidia light to dark-brown, immersed or superficial, sub-globose to globose, ostiolate , with short neck, 150-500 µm; conidia hyaline, 1-celled, cylindrical with obtuse ends, usually biguttulate, 3.5-7 X 2-3 µm.

6. P. viburnii (Roum. ex Sacc.) Boerema & Griffin, in Trans. Br. Mycol. Soc. 63 (1): 109-114, 1974.

Cultural characteristics:

Colonies with velvety appearence olivaceous-grey to grey-olivaceous, in the centre with much aerial mycelium (2-3 mm raised above the agar surface), a band of whitish mycelium at the margins, reverse with faint honey colouration in the agar, attaining a dia. of 6.5-8 cm on oat-agar in 7-days; conidia hyaline, 1-celled, 3.5-8.5 X 1.5-3.5 µm in dia.

Boerema and Griffin (1974) stated that it is only with much experience that P. viburni can be distinguished with certainty from P. exigua var. inoxydabilis and P. macrostoma var. incolorata.

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THE HYPHOMYCETE GENUS *CLADORRHINUM* AND ITS TELEOMORPH CONNECTIONS

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ABSTRACT — The genus *Cladorrhinum* Sacc. & Marchal is characterized by the possession of clustered fertile hyphae, each cell of which possesses a lateral phialidic opening (pleurophialides). The genus *Bahupaathra* Subram. & Lodha, type species *B. samala*, is synonymized with it. The genus is connected with teleomorphs of *Apiosordaria* and *Cercophora* in the Lasiosphaeriaceae, which are reviewed.

Apart from the type species, *C. foecundissimum* Sacc. & Marchal, four other anamorphic species are recognized, *C. bulbillosum* W. Gams & Mouchacca *sp. nov.*, *C. phialophoroides* Mouchacca & W. Gams *sp. nov.*, *C. samala* (Subram. & Lodha) W. Gams & Mouchacca, *comb. nov.*, and *C. brunnescens* W. Gams. The remaining two distinguishable *Cladorrhinum* species have been connected with teleomorphs: the aggregate anamorph of several *Apiosordaria* species and the anamorph of *Cercophora samala* Udagawa & Muroi originally proposed as being identical to *C. samala*. The latter ascomycete proved, however, to be heterothallic and its mating strains were found to be incompatible with the morphologically distinct *Cladorrhinum samala* for which no teleomorph has yet been discovered.

KEY WORDS: *Cladorrhinum, Bahupaathra, Apiosordaria, Cercophora*, Lasiosphaeriaceae, Sordariaceae, Hyphomycetes, phialide, revision, taxonomy, teleomorph connections.

INTRODUCTION

The anamorphic genus

The hyphomycete genus *Cladorrhinum*, type species *C. foecundissimum*, was established by Saccardo and Marchal (in Marchal, 1885) for a fungus observed on dung collected in the Ardennes region (Belgium). This fungus had been observed several times by Marchal since the information concerning the collecting dates extends over three years. Just one year after the original publication, Saccardo (1886) in the Sylloge Fungorum reproduced the same brief diagnosis of the genus and the type species.

The original spelling of the genus contained a single *'r'*, but this was already corrected by Saccardo (1886), according to the rules of Greek grammar (compound nouns of which the second starts with letter 'rho', ρ), into double 'rr'; subsequent authors [Karsten (1892), Clements (1909), Clements and Shear (1931), Von Arx and Gams (1967) and many subsequent authors, with the only exception of the 'Index Nominum Genericorum' (Farr *et al.*, 1979) and the 'Dictionary of Fungi' (Hawksworth *et al.*, 1983)] have followed this spelling. Because of this obviously current and linguistically correct use, it was decided to retain the spelling with double *'rr'* in the forthcoming list of 'Generic names in current use' (P. M. Kirk, pers. comm.) and we adhere to this decision.

The type species, *C. foecundissimum*, was apparently ignored until 1967, when Von Arx and Gams reevaluated the taxonomic position of the ascomycete *Pleurage verruculosa* C. N. Jensen (1912). Cultures of its anamorph could then be compared only with the published protologue of *C. foecundissimum*, since the original material preserved at BR no longer contained a fungus matching the description. The anamorph of *Pleurage verruculosa* could be placed in *Cladorrhinum* but proved to be morphologically distinct from the type species. Cannon *et al.* (1985), quoting Udagawa and Furuya (1972), listed the former taxon as teleomorph of the latter though no specific identification of the anamorph had been undertaken by the Japanese authors. Von Arx and Gams (*l.c.*) amended the generic description and introduced the term pleurophialide to designate the short intercalary phialides provided with flaring collarettes. *C. foecundissimum* and three unnamed species were repeatedly isolated by Gams and Domsch (1969) during ecological studies of the soil mycoflora of two wheat fields in Germany.

In 1964, Subramanian and Lodha described the genus *Bahupaathra,* type species *B. samala,* for a hyphomycete observed on steamed and unsteamed cow dung collected in India. Besides conidia aggregated in slimy balls from short lateral peg-like phialides, well-developed dark, thick-walled hyphae were also observed. Von Arx and Gams (1967) suggested that *Bahupaathra* might be congeneric with *Cladorrhinum,* and Von Arx (1970) listed the two genera as synonymous, whilst Ellis (1971) retained them as distinct.

The discovery of some further species in Egyptian and European soils prompted the present study.

The associated teleomorph-genera

The genus *Apiosordaria* was introduced as a member of the Sordariaceae by Von Arx and Gams (1967) for *Pleurage verruculosa* C. N. Jensen and characterized by the possession of 2-celled ascospores, the apical cell of which is larger, pigmented, ornamented, and contains a conspicuous apical germ pore; no appendages are present. Later it was classified in the Lasiosphaeriaceae by Lundqvist (1972). This classification is also recognized by Eriksson & Hawksworth (1990). Two similar genera were published soon afterwards: *Lacunospora* Cailleux (1968), characterized by having pitted ascospores with a minute basal cell and evanescent gelatinous basal and apical appendages, and *Jugulospora* Lundqvist (1972), characterized by dark, ornamented ascospores with a minute, finally collapsing, hyaline basal cell. These two genera were later merged with *Apiosordaria* by Von Arx (1981). Another similar genus, *Echinopodospora* Robison (1970), was distinguished on the basis of having non-ostiolate ascomata, (see also Jong and Davis, 1974), but this criterion was not recognized as warranting generic distinction by Krug *et al.* (1983), who revised all so far known species of *Apiosordaria* in this broader sense. They recognized 16 taxa, not all of which have anamorphs in *Cladorrhinum.*

Since this revision, *Apiosordaria tenuilacunata* Guarro *et al.* (1984) was described without mention of an anamorph, though we observed *Cladorrhinum* sp. conidiophores in an authentic isolate, CBS 628.82. This fungus was later found to match *Triangularia backusii* Huang (Huang, 1975) and therefore was renamed *A. backusii* (Huang) Guarro (Guarro and

Cano, 1988). Three further species were transferred from *Triangularia* Boedijn to *Apiosordaria* by Guarro and Cano (1988): *T. angulispora* Cain & Farrow 1956, *T. obliqua* Cain & Farrow 1956 and *T. striatispora* Furuya & Udagawa 1971; none of these was associated with an anamorph, though for the first one scattered phialides had been described by Cain and Farrow (1956). According to Guarro and Cano (1988), the two genera were delimited by having either smooth ascospore walls (*Triangularia*) or ornamented, striate, pitted or verrucose walls (*Apiosordaria*) in the upper ascospore cell. In species of *Triangularia* in this sense no *Cladorrhinum* anamorph is known so far. *Apiosordaria otanii* Udagawa (1990) was described with a *Chrysosporium*-like anamorph.

A *Cladorrhinum*-type anamorph was illustrated but not named for *Arnium calymmatosporum* Jeng & Krug (1977). *Cladorrhinum*-like phialides (but not aggregated into clusters) may also occur in *Podospora* (Mirza and Cain, 1969) and *Apodospora* (Cain and Mirza, 1970), but the conidia are not capable of germinating.

Finally, Udagawa and Muroi (1979) described the ascomycete *Cercophora samala*. Cultures of this fungus produced an anamorph regarded by the authors as conspecific with *Bahupaathra samala*. This teleomorph-genus of the Lasiosphaeriaceae (see also Lundqvist, 1972) differs from *Apiosordaria* by having septate or non-septate smooth-walled ascospores having long cellular basal and gelatinous apical appendages. Apparently *C. samala* is the only species of the genus so far known to have an anamorph that fits in *Cladorrhinum*.

The genus and species concepts for the anamorphs

The most distinctive features of *Cladorrhinum* include: rather fast-growing colonies, tufted or pustular conidiophore complexes consisting of aggregated, hyaline or subhyaline pale ochraceous conidiophores, each cell of which has a lateral phialidic opening (pleurophialides) and slimy (sub-) hyaline, smooth-walled phialoconidia. The regular occurrence of pleurophialides and the tufted aggregation of the conidiophores serve to distinguish the genus from *Phialophora* Medlar and from the anamorphs of *Podospora* and *Apodospora*. Some *Phialophora* species have dacryoid conidia; however, they do not form pustular aggregations and mostly have discrete phialides. The *Myrioconium* Sydow anamorphs of various Sclerotiniaceae have sporodochium-like conidiophore aggregates with often globose conidia, which are perfectly hyaline. The intercalary phialides of *Lecythophora* Nannf. (in Melin & Nannfeldt, 1934), which were considered most characteristic of this genus by Gams & McGinnis (1983), have shorter lateral openings without flaring collarettes; sporulation is not pustular in this genus, but usually in slimy masses. The genus mainly comprises anamorphs of *Coniochaeta* (Sacc.) Cooke, a genus not related to the teleomorphs of *Cladorrhinum*.

The above-mentioned production of *Chrysosporium*-like solitary blastoconidia from intercalary hyphal cells in some species of *Apiosordaria* seems to represent some kind of reduction of the intercalary phialides of *Cladorrhinum*, where the conidiogenous opening, after producing a single conidium, becomes blocked (see Gams, 1973). We have observed the joint occurrence of these blastoconidia together with phialoconidia in some isolates for which we expect an *Apiosordaria* affinity but refrain from formally naming them in *Cladorrhinum*.

Some isolates of the first unnamed species from German and Dutch agricultural soils ascribed by Gams and Domsch (1969) to *Cladorrhinum* are described here as a new species, *C. brunnescens*; those of the second proved not to be typical of the genus because of slower growth, little tufted aggregation of conidiophores, and predominant discrete plagiotropic phialides. They rather fit *Phaeostalagmus* and will be described in a separate paper. The third species resembled the here described *C. bulbillosum* but the respective isolates are no longer available in reliable condition.

If *Cladorrhinum* and *Bahupaathra* are to be distinguished generically, according to their teleomorph relationships, the following criteria are available: a) the presence of dark and thick-walled vegetative hyphae, basal to or independent from the conidiophores, and b) the localization of the pleurophialides on a branched system of secondary branches, rather than on the primary hyphae as in *C. foecundissimum*. The latter criterion was found to apply to some of the new species to be described here, which consistently lacked the dark, thick-walled hyphae and would therefore be difficult to classify. The presence of dark brown hyphae is unstable and unreliable, even within the same isolate, and thus of limited diagnostic value. The pale ochraceous pigmentation of the phialidic conidiophores is the same in both groups. As we are still far away from a natural classification of *Phialo-*

phora-like anamorphs, we prefer to unite all the anamorphs so far discussed in the single genus *Cladorrhinum*.

Cladorrhinum has a limited number of characters suited to distinguish species. Isolates of the same taxon (species) are highly variable in pigmentation, amount of sporulation and sclerotial formation. In spite of all variation we found that three groups of pigmentation patterns can be distinguished: a) those with some green or olivaceous tints in the submerged mycelium, but also partly ochraceous-orange, b) those producing (olive-) brown pigment mainly in lanose aerial but not in submerged mycelium, and c) those lacking greenish hues but ranging from whitish to ochraceous-orange to more or less dark brown. Besides this, the colonies can appear more or less black due to the formation of submerged microsclerotia. The degree of pigmentation in the cell aggregates or microsclerotia seems to be stable, and so is the shape of the conidia, either dacryoid and almost as broad as long, or short-clavate to ellipsoidal.

We distinguish here five rather sharply delimited anamorph-species, but are aware of the existence of some deviating isolates which we so far refrain from formally describing as new taxa.

GENERIC DIAGNOSIS

Cladorrhinum Sacc. & Marchal, Bull. Soc. r. Bot. Belg. 24: 65. 1885.
syn. *Bahupaathra* Subram. & Lodha, Antonie van Leeuwenhoek 30: 329. 1964.

Colonies spreading broadly. Mycelium differentiated into wide runner hyphae and narrower hyphae, with pale or dark greenish or brownish pigmentation, sometimes darker hyphae or microsclerotia present. Fertile hyphae forming densely branched tufts, consisting of a series of intercalary phialides with lateral openings and end-cells with terminal or lateral openings, usually each with flaring collarettes. Conidia continuous, dacryoid to ellipsoid, hyaline or subhyaline, smooth-walled, adhering in slimy balls, often unable to germinate (spermatial function).
Type species *Cladorrhinum foecundissimum* Sacc. & Marchal.

Note: Species with solitary blastoconidia arising laterally from hyphal cells are not specifically included in this revision.

It is sometimes difficult to observe good sporulation in species of *Cladorrhinum*. The most suitable media to induce sporulation are oatmeal (OA), cornmeal (CMA) or potato–carrot (PCA) agars, while 2% malt extract agar (MEA) is slightly less suitable; incubation at 21-24°C with light or near-UV promotes sporulation too.

THE ACCEPTED SPECIES

KEY TO THE SPECIES

1. Blackish microsclerotia usually abundant in the agar 2
   Blackish microsclerotia absent, but aggregates of brown or pale swollen cells may be present 3

2. Colonies fast-growing with growth occurring up to 40°C; microsclerotia mostly abundant; fertile hyphae almost exclusively with lateral phialidic necks; conidia dacryoid . . . . 3. *C. bulbillosum*
   Colonies rather slow-growing (40 mm diam in 10 days), no growth above 36°C; sclerotial masses of various shapes and less abundant; fertile hyphae often ending in straight, discrete phialides; conidia elongate, clavate to ellipsoid . . . 4. *C. phialophoroides*

3. Colonies with green to olivaceous tints, mainly in submerged parts; fertile hyphae forming extended complexes 4
   Colonies lacking green to olivaceous tints in the substrate, pinkish ochraceous, sometimes with patches of (olivaceous-)brown aerial mycelium; clusters of fertile hyphae appearing as localized lateral branches of vegetative hyphae 5

4. Conidia dacryoid to globose . . . . 1. *C. foecundissimum*
   Conidia ellipsoid . . . . 2. anamorphs of *Apiosordaria* spp.

5. Conidia dacryoid to globose 6
Conidia elongate, short clavate to ellipsoidal
. . . . 6. anamorph of *Cercophora samala*

6. Colonies slow-growing; (olivaceous-)brown aerial mycelium commonly produced; sporulation appearing tardily in localized patches
. . . . 7. *C. brunnescens*
Colonies fast-growing (90 mm diam in 6 days at 25°C); brown pigmentation often appearing in sporulating patches, but not in sterile areas . . . . 5. *C. samala*

1. *Cladorrhinum foecundissimum* Sacc. & Marchal, Bull. Soc. r. Bot. Belg. 24: 65. 1885. — Fig. 1.

Colonies spreading broadly, reaching 50–65 mm diam in 5 days on 2% MEA or OA at 20°C, 30–55 mm in 3 days at 25°C; aerial mycelium floccose, greyish to pinkish ochraceous. Reverse yellowish to greenish to olivaceous–black. Runner hyphae 6–8 μm wide. Clusters of swollen hyaline vegetative hyphae commonly occurring. Extensive masses of fertile cells forming floccose pale ochraceous aggregations on OA or PCA, densely branched at wide angles, hyaline or slightly pigmented, the cells measuring 5–11 × 2.5–3.5(–4.5) μm, each cell bearing a lateral neck, 1–4(–10) μm long, usually with a flaring collarette, the terminal cell usually also with a lateral, sometimes a terminal opening. Conidia dacryoid to almost globose, mostly guttulate, (sub-)hyaline, 3–3.5 × 2.5–3 μm, gathering in slimy balls.

Mating experiments carried out among numerous fresh isolates were not successful.

Temperature optimum for growth 24–27°C, maximum 32°C.

MATERIAL EXAMINED:

CBS 180.66, designated as *neotypus* (herb. CBS) by Von Arx and Gams (1967), and 181.66, isolated by J.H. van Emden, from agricultural soil, Wageningen, the Netherlands, July 1965.

CBS 182.66 and numerous other isolates obtained from wheat-field soil, Kiel-Kitzeberg, Germany, by W. Gams, 1962.

CBS 183.66, isolated by M.B. Schol-Schwarz from textiles buried in Dutch soil samples kept at 31°C.

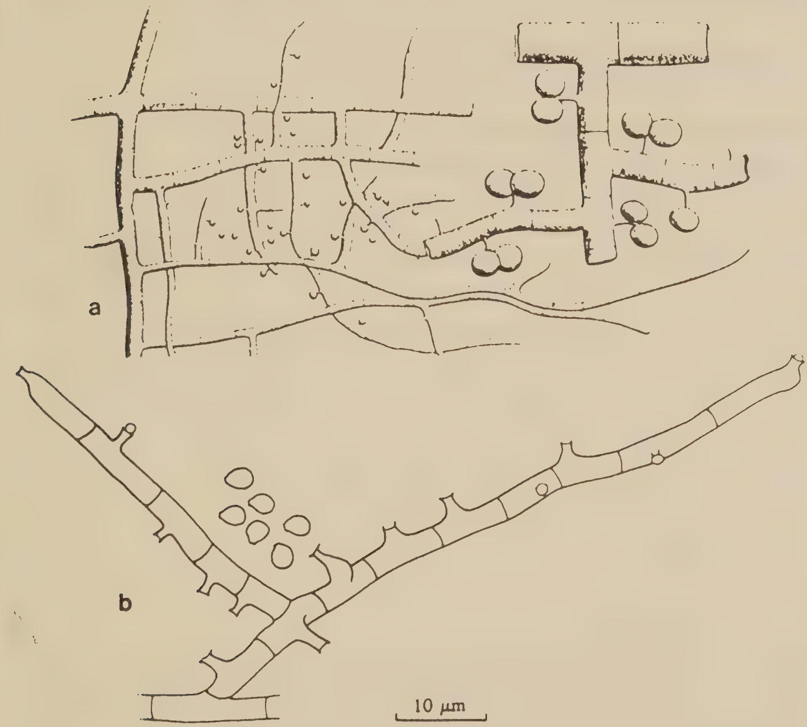


Fig. 1. a. original illustration of *Cladorrhinum foecundissimum*, from Marchal (1885); b. conidiophores and conidia from a fresh isolate.

The pagination of the protologue varies in different citations: In the original publication as an issue of the journal, the page number is 65; in the reprints distributed of the same paper it is 32.

The conidia do not germinate. Therefore this common soil fungus is hardly ever recovered with soil dilution plates.

C. foecundissimum was again described and documented by Domsch *et al.* (1980) and reported from dead stems of *Eleocharis palustris* in Hungary by Holubová-Jechová (1979). No other reports are known to us since then.

2. *Cladorrhinum* states of *Apiosordaria* species

The anamorphs of *A. verruculosa* (C. N. Jensen) v. Arx & W. Gams, with its varieties *verruculosa* and *maritima* (Apinis & Chesters) v. Arx & W. Gams, and some related species are hardly distinguishable (Von Arx and Gams, 1967; Udagawa and Furuya, 1972, 1975), all having elongate, faintly dacryoid, ovoid to ellipsoid conidia, measuring 3–3.5 × 2–2.5 μm. The colonies for the rest perfectly match those of *C. foecundissimum*. According to the literature, other *Apiosordaria* species having this kind of anamorph include: *A. tetraspora* Krug *et al.* (1983), *A. vestita* Udagawa & Horie (1982), *A. longicaudata* (Furuya & Udagawa) Krug *et al.* (1983) (= *Lacunospora longicaudata* Furuya & Udagawa apud Furuya 1978), and *A. backusii* (Huang) Guarro (apud Guarro & Cano, 1988). The last species differs from the others by almost black colonies.

Temperature optimum for *A. verruculosa* var. *verruculosa* 24–30°C, maximum 35°C.

MATERIAL EXAMINED:

A. verruculosa var. *verruculosa*, CBS 432.64 and 433.64, a pair of compatible isolates, and CBS 184.66, a mixture of compatible isolates, both from agricultural soil at Kiel-Kitzeberg, FRG, isol. W. Gams. CBS 148.77 and 149.77, from soil, Niyako-shi, Japan, isol. K. Furuya (for more isolates see Von Arx & Gams, 1967).

A. verruculosa var. *maritima*, CBS 550.66 (ex-type), from soil, Gibraltar Point, Lincs., UK, isol. A. E. Apinis. CBS 335.74, from wheat root, Lienden, Netherlands, isol. C. L. de Graaff.

A. tetraspora, CBS 363.84 (ex-type), from soil, Nonsung, Thailand, isol. S. Udagawa. CBS 411.82, from cow dung, Edo. Bolivar, Venezuela, isol. J. C. Krug.

A. vestita, CBS 135.91 = NHL 2710 (ex-type), from soil, Neche, eastern Nepal, Sep. 1971. coll. M. Osawa. Rather slow-growing, with olivaceous mycelium, now generally remaining sterile.

A. longicaudata, CBS 390.84 (ex-type), from soil, Ishigaka Island, Japan, isol. T. Watanabe.

A. backusii, CBS 539.89 (ex-type), from soil, Montgomery Co., Ohio, USA, isol. L. H. Huang; CBS 106.77, from soil, Okinawa Pref., Japan, isol. J. Horie; CBS 540.89, from rabbit dung, Castilleos, Terragona, Spain, isol. J. Guarro.

Some species formerly placed in *Echinopodospora*, *A. vermicularis* (Morinaga *et al.*) Krug *et al.*, and *A. effusa* (Morinaga *et al.*) Krug *et al.*, have both a *Cladorrhinum* anamorph and solitary lateral holoblastic conidia that have been referred to *Chrysosporium* by Jong and Davis (1974) and Morinaga *et al.* (1978). Others [*A. terrestris* (Jong & Davis) Krug *et al.*] have only the *Chrysosporium*-like conidia. Similar synanamorphs have been observed in some species of *Thielavia* Zopf (Von Arx, 1975).

We refrain from applying specific epithets to these anamorphs, as it is mostly rather easy to induce a teleomorph by cultivation under black light and/or mating of compatible isolates.

The spermatial nature of the conidia was demonstrated by Von Arx and Gams (1967).

A. verruculosa was again described and documented by Domsch *et al.* (1980). The ornamentation of its ascospores was shown to originate in the perispore layer (Bellemère *et al.*, 1992).

3. *Cladorrhinum bulbillosum* W. Gams & Mouchacca, *sp. nov.* — Fig. 2.

Coloniae ad 60–80 mm diam post 3 dies 25°C, primum hyalinae, deinde microsclerotiis formatis nigrescentes. Microsclerotia numerosa, plerumque in agaro submersa, discreta vel confluentia, subglobosa vel forma irregularia, atrobrunnea, ad 100–150 μm diam. Reversum viride vel caeruleo-atrum. Mycelium ex hyphis radiantibus, plus minusve pigmentatis, 5–12 (–15) μm latis et hyphis secundariis hyalinis, 2–3 μm latis compositum. Hyphae fertiles e ramis lateralibus identidem ramosis oriundae, in floccis aggregatae, plus minusve pigmentatae; saepe sinuosae, 2–4 μm latae, cellulae 5–10 μm longae, collulo phialidico laterali 2–2.5 × 1–1.5 μm et margine patente praeditae. Conidia dacryoidea, hyalina, acervata dilute ochracea, in capitulis mucidis aggregata, ad basim truncata, 2.5–3.5 × 1.5–2.5 μm.

Typus CBS 304.90, exsiccatus et vivus, isolatus ex arena Deserti Occidentalis, Oasis Dakhla dictae, in Aegypto.

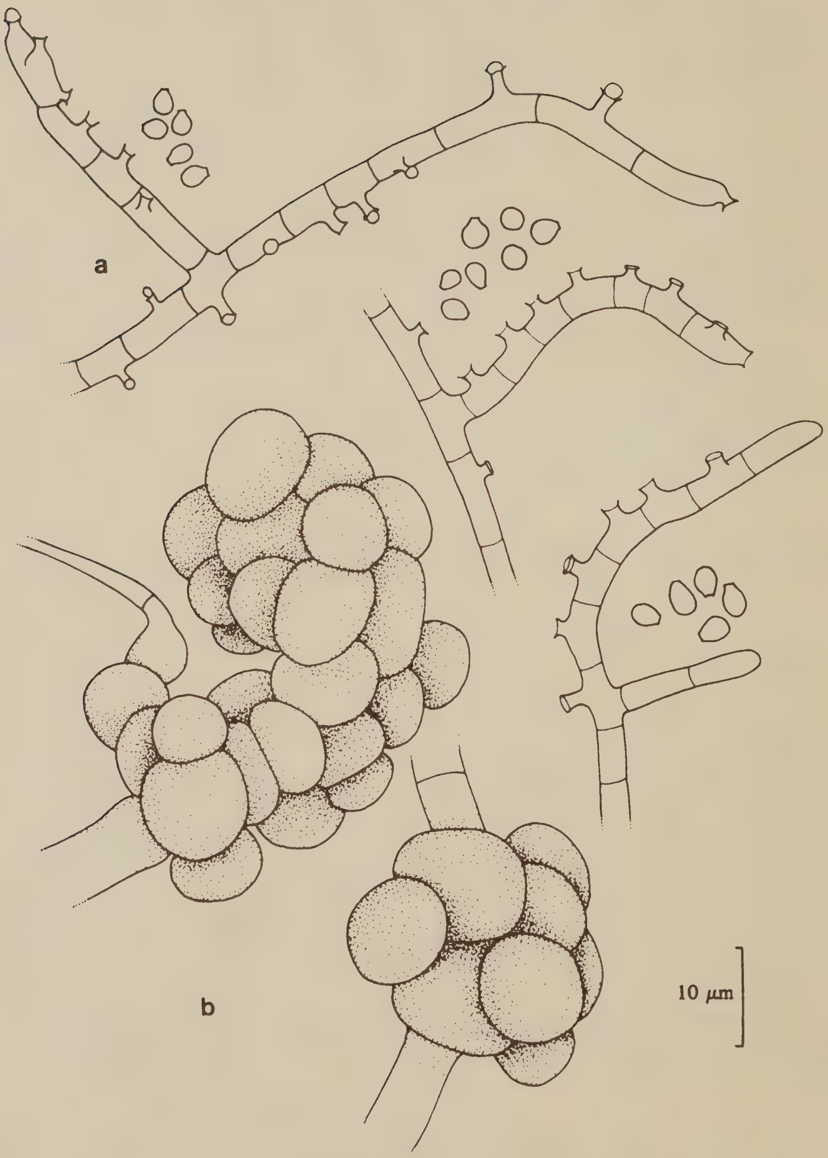


Fig. 2. *Cladorrhinum bulbillosum*, a. conidiophores and conidia, b. microsclerotia, CBS 267.76.

Colonies spreading rapidly, reaching 60–80 mm diam in 3 days at 25°C on 2% MEA; at first colourless, then blackening from the edge towards the centre with the formation of mostly submerged masses of microsclerotia, after 2–3 days incubation. Microsclerotia numerous, mostly submerged in the agar, separate or confluent, subglobose to irregularly shaped, blackish brown, up to 100–150 μm diam, made up of rounded to subglobose or polygonal, dark-walled cells, up to 20 μm diam. Sclerotial cells initiated by a process of lateral budding from cells of runner hyphae. Microsclerotia showing no sign of tissue differentiation. Reverse greenish- or bluish black. Mycelium consisting of either greenish black, rather thick-walled, runner hyphae, 5–12(–15) μm wide, or thin-walled, hyaline, 2–3 μm wide lateral hyphae. Runner hyphae simple or aggregated into strands, finally forming a sheet on the agar surface. Hyphae with moniliform, swollen cells sometimes present.

Fertile hyphae originating as localized clusters of lateral branches from hyaline or more or less densely melanized hyphae; repeated more or less rectangular branching leading to the production of whitish to pale buff pustules of interwoven fertile hyphae. Fertile hyphae sinuous, hyaline or slightly pigmented, 2–4 μm wide, made up of 5–10 μm long cells, each provided with a single, rarely two, lateral conidiogenous openings, the end-cell also mostly bearing a lateral subterminal (rarely terminal) opening; phialide cells cylindrical, 5.5–11 × 2–4 μm, lateral necks 2–2.5 × 1–1.5 μm, provided with a distinct flaring collarette, 1.5–2 μm in width. Conidia continuous, hyaline, dacryoid, 2.5–3.5 × 1.5–2.5 μm, gathered in slimy balls; conidial base truncate, 0.7–1.0 μm wide. Conidial masses appearing pale ochraceous.

Temperature optimum 27–36°C, maximum above 40°C.

Mating in all possible combinations and incubation under near-UV at 24°C did not yield any ascomata. CBS 604.75 agrees in every respect, also the high temperature maximum and rapid growth, with the Egyption isolates.

MATERIAL EXAMINED:

CBS 604.75, isolated from the eye of an 8-year-old child in Argentina by F. Scattini and sent in by R. C. Zapater (Zapater and Scattini, 1979).

CBS 267.76, isolated from root of *Saccharum officinarum* by T. Watanabe, in Taiwan (see Watanabe, 1975); the isolate initially formed numerous dark microscle-

rotia; it has almost completely lost this capacity, but still shows the high growth temperature tolerance characteristic of the species.
CBS 294.90–299.90, 304.90 (type), isolated by J. Mouchacca from soil of abandoned fields, Dakhla Oasis, New Valley region, Western Desert, Egypt.

4. *Cladorrhinum phialophoroides* Mouchacca & W. Gams, *sp. nov.* — Fig. 3.

Coloniae ad 40 mm diam post 10 dies 25°C, velutinae, mycelio aerio tenui albido coopertae; reversum primum hyalinum, deinde sclerotiis nigromaculatum. Microsclerotia primum ad 100 μm diam, sed nonnumquam multo majora. Mycelium ex hyphis radiantibus, dilute brunneis ad brunneis, ad 18 μm latis, et hyphis secundariis dense ramosis, 2–4 μm latis, tenuitunicatis, hyalinis vel flavidis. Hyphae fertiles 1.5–3.3 μm latae, partim pigmentatae, aggregatae, simplices vel ramosae et phialides terminales vel laterales ferentes. Phialides terminales frequentes, lageniformes, hyalinae, rectae vel modicae sinuosae, 10–20 × 2–2.5 μm, in collare inconspicuum exeuntes; phialides intercalares collulum conidiogenum iuxta septum ferentes, 2–4 × 1–1.5 μm. Conidia continua, hyalina, breviter clavata vel ellipsoidea, 2–3.5(–4) × 1–1.5 μm, ad basim truncata, in capitulis mucidis coherentia.
Typus CBS 301.90, exsiccatus et vivus, isolatus ex arena deserti in campo *Tritici*, Oasis Dakhla, in regione New Valley in Aegypto.

Colonies growing comparatively slowly, reaching 40 mm diam in 10 days at 25°C on 2% MEA, velvety, covered with a thin layer of whitish aerial

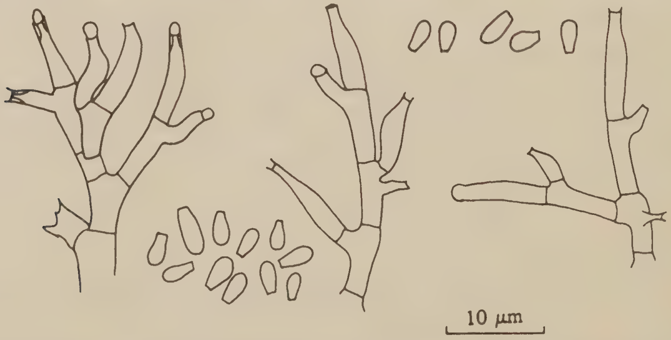


Fig. 3. *Cladorrhinum phialophoroides*, conidiophores and conidia, CBS 301.90.

mycelium; reverse hyaline at first, becoming mottled dark bluish black due to the formation of separate, rarely confluent brownish black sclerotial masses, initially about 100 μm diam but sometimes becoming much larger. Sclerotial masses made up of rounded to polygonal, thick-walled, dark brown cells, 10–20 μm diam. Mycelium consisting of up to 18 μm wide, light brown to brownish black runner hyphae and more densely branched, 2–4 μm wide, thin-walled, hyaline to slightly thick-walled yellowish hyphae.

Fertile hyphae 1.5–3.5 μm wide, partly pigmented, tufted, simple or branched and bearing terminal or lateral phialides. Terminal phialides rather common, flask-shaped, hyaline, straight to slightly sinuous, 10–20 μm long, 2–2.5 μm wide at the base, apex with an indistinct collarette; intercalary phialides appear bearing lateral conidiogenous openings just under the septum, 2–4 × 1–1.5 μm; polyphialides rather uncommon. Conidia continuous, hyaline, short-clavate to ellipsoid, (less commonly cylindrical to subglobose), 2–3.5(–4) × 1–1.5 μm, with a truncate base 1–1.5 μm diam, adhering in slimy masses.

Temperature optimum 27°C, maximum 36°C. Mating of the two available isolates did not yield any ascomata.

MATERIAL EXAMINED:

CBS 300.90 and 301.90 (type), isolated by J. Mouchacca from desert soil under wheat, Dakhla Oasis, New Valley region, Western Desert, Egypt.

CBS 290.75, isolated from *Musa* sp. by Adil Cengiz, Adana, Turkey, 1975. Deviating by conidiophores which are closer to *C. bulbillosum* (short phialidic cells), but the conidia are ellipsoidal and growth is slower.

5. *Cladorrhinum samala* (Subram. & Lodha) W. Gams & Mouchacca, *comb. nov.* — Figs 4, 5.

Basionym: *Bahupaathra samala* Subram. & Lodha, Antonie van Leeuwenhoek 30: 329. 1964.

Colonies of very irregular shape and structure, reaching 60–90 mm diam in 6 days at 25°C, pale brown, cottony, partly denser, with pinkish pustules. Reverse partly dark brown. Mycelium consisting of broad runner hyphae, up to 6–10 μm wide, and narrower hyphae of about 2.5 μm width. Characteristic of the species is the frequent presence of dark brown, smooth- and thick-walled hyphae, 2.5–4 μm wide. Clusters of swollen hyphae commonly occurring, in old colonies also irregular sclerotium-like aggregates. Fertile hyphae originating as localized clusters of dense lateral branches from darker vegetative hyphae, hyaline or pigmented; repeated more or less rectangular branching in several orders leading to the production of whitish pustules of interwoven fertile hyphae; cells cylindrical or barrel-shaped, 5–11 × 2–3.5 μm; end-cells with terminal or lateral opening; the lateral necks 1–3(–8) μm long, bearing a flaring collarette; rarely discrete phialides 8–12 × 2.5–3.5 μm, present. Conidia dacryoid, (sub-)hyaline, (2–)3–3.5(–4) × (1.5–)2–2.5(–3) μm.

Temperature optimum 27–33°C, maximum 38°C (some isolates survive 40°C for 2 days).

MATERIAL EXAMINED:

IMI 113129 (ex RUBL 66, type), dried type material of *B. samala*, from cow dung in Chakrata, Mussoorie Hills, U.P., India.

CBS 213.72, isolated from *Dianthus caryophyllus* in Bornova-Izmir, Turkey, by Necati Kaşkaloglu.

CBS 524.72, 302.90 and 303.90, isolated by J. Mouchacca, from cultivated desert soil under wheat, Dakhla Oasis, Western Desert, Egypt.

CBS 266.76, isolated from root of *Saccharum officinarum* by T. Watanabe, in Taiwan (see Watanabe, 1975), deviating by forming some intercalary, hyaline, thick-walled chlamydospores, 6-14 μm diam.

CBS 388.77, isolated from inflorescence of *Macadamia integrifolia,* Guatemala, plantation of Hawaii Agron. International, sent by W. Nicolai, 1977. Deviating by abundant formation of white hyphal tufts and some very dark submerged hyphae.

CBS 382.78 A and B, isolated from maize-field soil, Columbia, Dep. Meta, near Villavicencio, coll. O. Rangel, isol. J. Veerkamp, 1978. Deviating by additional formation of *Chrysosporium*-like blastoconidia.

CBS 295.79 = LEV 14454b, isolated from soil, Levin, New Zealand, by G.F. Laundon, 1979; deviating by production of richly branching aggregates of dark brown hardly inflated hyphae in the agar.

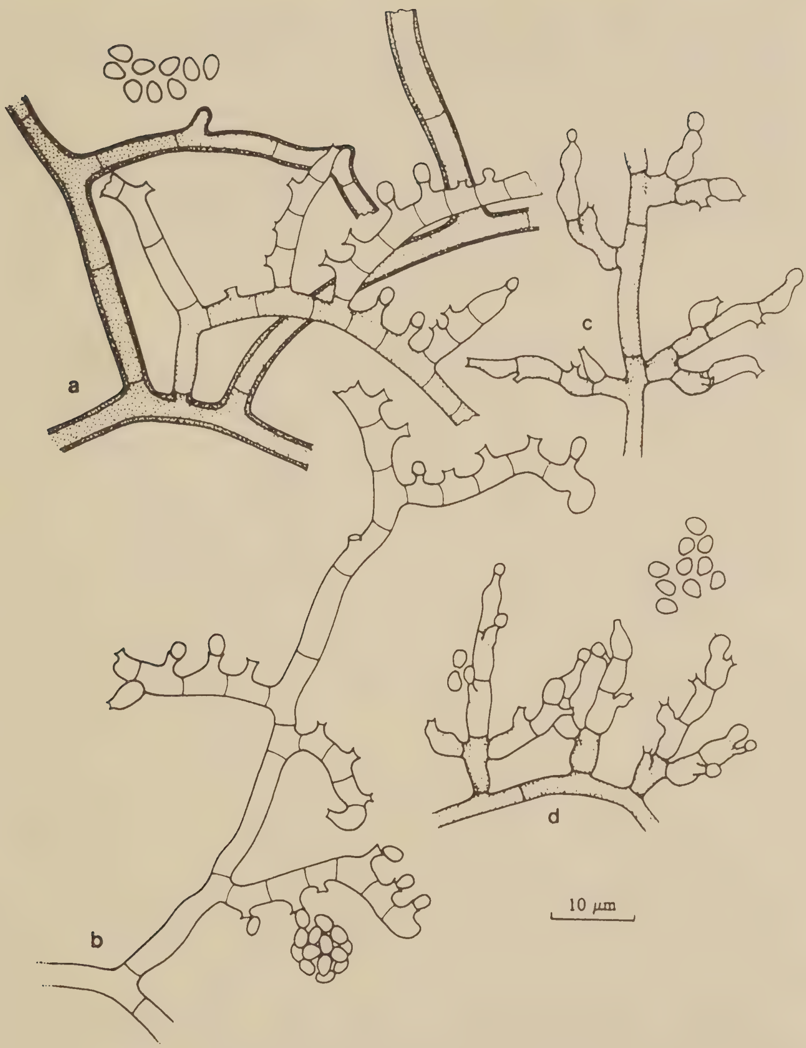


Fig. 4. *Cladorrhinum samala*, conidiophores and conidia, a and b. from type, IMI 113129, c and d. CBS 524.72.

CBS 380.85, isolated from elk dung by C.T. Rogerson, Weber County, along Wolf Creek, Eden, New York, U.S.A. (C.T.R. 65-4); deviating by producing some discrete very broad almost globose phialides.
CBS 307.92, isolate 8-29 by J. M., originally producing non-ostiolate ascomata reminiscent of *Apiosordara tetraspora*; CBS 308.92 = isolate F-6 by J. M., and CBS 309.92 = isolate F-10 by J. M., all three from a clay soil in a plot with soya plants at the Agricultural Research Centre IRAT, Port LaGuerre, New Caledonia; the latter deviating by production of a few single-celled chlamydospores.

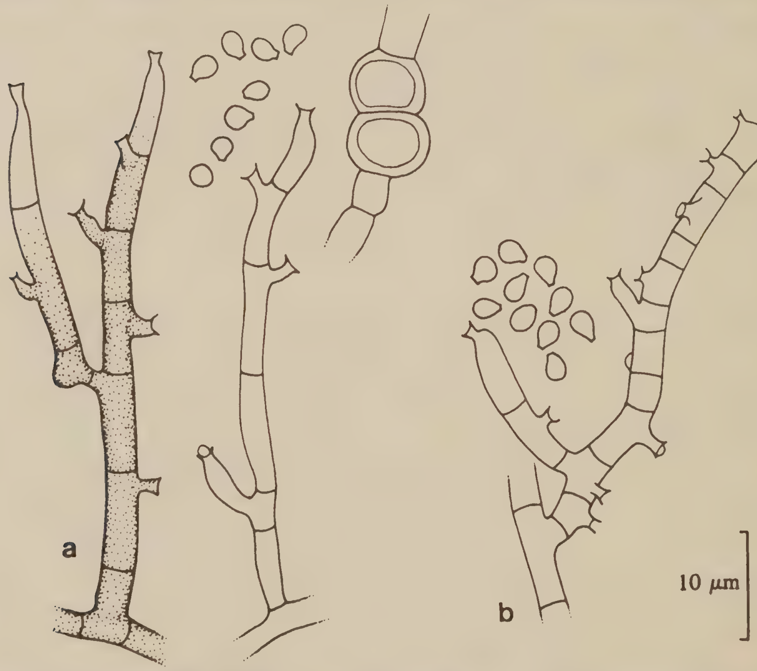


Fig. 5. *Cladorrhinum samala*, conidiophores and conidia, a. CBS 266.76, b. CBS 382.78B.

This species is very variable in cultural aspect. It tends to lose both the production of dark hyphae and sporulation capacity after repeated transfer. The delimitation is not yet satisfactorily settled and it is possible that several ascomycete anamorphs have been aggregated under the present diagnosis. In any case, none of the isolates listed reacted sexually with the mating partners of *Cercophora samala* (see below).

6. Anamorph of *Cercophora samala* — Fig. 6.

Cercophora samala Udagawa & Muroi, Trans. mycol. Soc. Japan 20: 454. 1979.

For description of the teleomorph we refer to Udagawa & Muroi (l.c.). Ascomata are regularly produced in vitro under black light, maturing on OA or CMA at 25°C in about 20 days. Ascospore body given as (17–) 19–22(–24) × 10–12(–13) μm and basal appendage as (32–)34–38(–40) × 4–6(–7) μm.

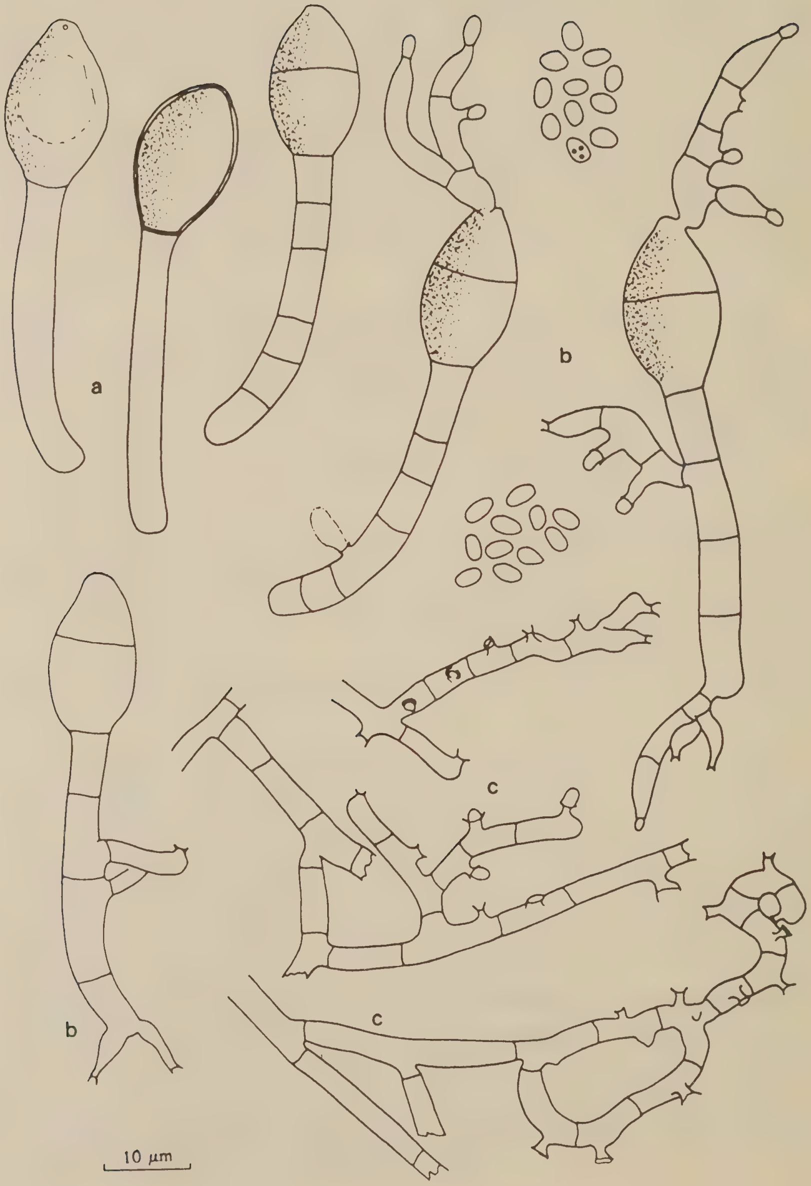
Morphology of the anamorph as in *Cladorrhinum samala*; colonies reaching 65 mm diam in 4 days on MEA at 25°C, sporulating mostly in compact pustules interspersed with brown setae; the conidia are elongate–ellipsoid, 3.5–4 × 2.0–2.5 μm.

Temperature optimum 27–33°C, maximum 36°C.

MATERIAL EXAMINED:
CBS 306.81 = NHL 2864, isolated from cow dung, Myokôkogen-cho, Nakakubiki-gun, Niigata Pref., Japan, by S. Udagawa, received as *Cercophora samala.*
CBS 307.81 = NHL 2865, type, isolated from cow dung, Happogahara, Yaita-shi, Tochigi Pref., Japan, leg. T. Muroi.
CBS 109.93 (mating type A), and 110.93 (mating type B), single-spore subcultures from CBS 307.81).

Ascomata of *Cercophora samala* were originally discovered *in vitro*. Ascoma production occurred in each of the two Japanese isolates when grown singly; it was enhanced after lyophilization and growth on OA at 24°C under black light. No information about a possible heterothallic behaviour was given in the original paper. Although it is very difficult to make single-ascospore isolates without contaminating conidia (spermatia), a few self-sterile subcultures were obtained in 1992 which showed segregation into two mating types. Hence this species is shown to be heterothallic. Additional mating experiments were then carried out with all strains hitherto classified as *C. samala*.

It is remarkable that these two isolates differ from those of *C. samala* in slightly longer and more ellipsoidal conidia. The fact that no teleomorph


a
b
b
c
c
10 µm

has ever been obtained in any of the isolates with short dacryoid conidia supports the taxonomic distinction, i.e. that *Cercophora samala* is not the teleomorph of *Cladorrhinum samala*. This difference is comparable to that between *C. foecundissimum* and the anamorph of *A. verruculosa*. The other properly studied species of *Cercophora* have other kinds of anamorph, but *Cercophora samala* still awaits comparison with the very similar *Bombardia pakistani* (Mirza) Cailleux (1971: 551) ≡ *Cleistobombardia pakistani* Mirza (1968). The ascospores are slightly smaller, the body given as (17–)19–21.5 (–24) × (11–)11.5–12.5(–14) µm; conidia as globose, 1.5–3 µm diam, formed on discrete phialides; ascomata partly non-ostiolate. No culture of *B. pakistani* is available. According to Cailleux, only dried material was examined from India at that time. He discarded the living culture when it stopped sporulating.

A congeneric ascomycete was described by Udagawa and Horie (1971: 516), collected on polypores in New Guinea, as *Bombardia ambigua* var. *carbonaria* Rehm, with slightly narrower ascospores (body (19–)20–22 × 8–10 µm), lacking ostiolar setae, and with a similar anamorph but with broader conidia indicated as *Cladorrhinum* sp. (lacking dark hyphae); this was obviously a misidentification as indicated by Lundqvist (1972: 114); this fungus has not yet officially been renamed.

7. ***Cladorrhinum brunnescens*** W. Gams, *sp. nov.* — Fig. 7.

Cladorrhinum sp. I W. Gams & Domsch (1969).

Coloniae fere lente crescentes, 15–17 mm diam in agaro maltoso post 6 dies, 25°C; primum hyalinae, deinde mycelio aerio lanoso brunnescentes. Microsclerotia et chlamydosporae absentes. Sporulatio tarda, paucis locis acervata, *Cladorrhino samalae* similis. Conidia dacryoidea, (sub-)hyalina, 2.0–2.5 µm diam.

Typus CBS 643.75A, exsiccatus et vivus, isolatus e fibra *Cocois nuciferae* terra agresti immersa in Neerlandia, a J. Antheunisse, 1975.

Fig. 6. *Cercophora samala*, a. ascospores, b. germinating ascospores, c. conidiophores and conidia, CBS 306.81.

Colonies spreading moderately fast, reaching 15–17 mm diam on MEA in 6 days at 25°C, at first colourless, then becoming (olivaceous-)brown due to abundant lanose aerial mycelium, consisting of medium brown, 2.5–3,5 µm wide hyphae. Microsclerotia and chlamydospores absent. Sporulation appearing tardily in localized pale ochraceous patches, very similar to *Cl. samala*; conidiophores pale ochraceous. Conidia dacryoid, (sub-)hyaline, 2.0–2.5 µm diam.

Temperature optimum 21–27°C, maximum about 32°C, 36°C is survived for 2 days.

MATERIAL EXAMINED:

CBS 574.74, isolate C 1084, from wheat-field soil, Kiel-Kitzeberg, Germany, W. Gams and K. H. Domsch, 1964.

CBS 643.75A (type) –C and 644.75, isolated from cocos fibres buried in soil, North-Holland, Netherlands, by J. Antheunisse.

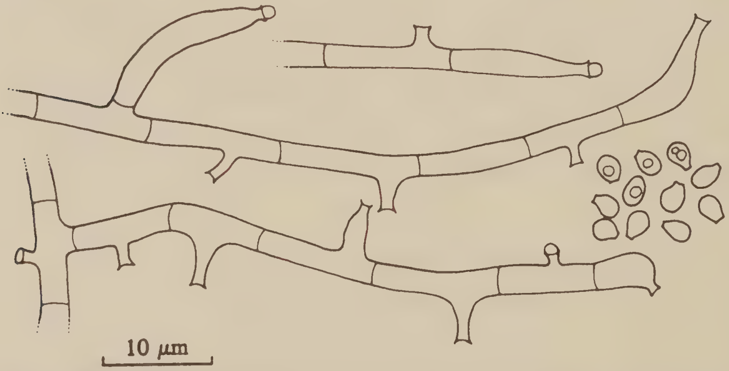


Fig. 7. *Cladorrhinum brunnescens*, conidiophores and conidia, CBS 574.74.

Excluded species

Cladorrhinum griseofulvum Karsten, Finlands Mögelsvampar, Bidr. Känned. Finl. Natur Folk 61: 542. 1892: after a study of the type material, this species was transferred to *Nodulisporium* Preuss by Hughes (1958).

Cladorrhinum ricini Garbowski, Bull. trimest. Soc. mycol. Fr. 39: 255. 1923, was described for a fungus forming dark spots on withering *Ricinus* *communis* leaves collected in the Crimea region. No type material of this could be traced in PC and the protologue is too meagre to allow identification.

Bahupaathra minuta Saxena & Mukerji, Mycopath. Mycol. appl. 49: 201. 1973. This species was isolated from Nilgai dung in Delhi, India, and described as differing from *B. samala* by its distinct, flask-shaped phialides producing smaller conidia and the absence of dark setae. Dried cultures of the type isolate deposited as IMI 141565 showed this to be the phialidic anamorph of a *Chaetomium* sp.

Acknowledgements
The authors are indebted to the curators of the herbaria PC and IMI who searched for specimens of the taxa discussed here, and the various mycologists mentioned in the text who contributed cultures. Efficient technical assistance to W. Gams was given by R. de Pagter. Drafts of the manuscript were kindly reviewed by Drs P. F. Cannon, D. W. Malloch and R. A. Samson.

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TWO NEW HYPHOMYCETES ISOLATED FROM ANTARCTIC LICHENS

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ABSTRACT – Two new species of hyphomycetes, *Chaunopycnis ovalispora* and *Acremonium psychrophilum*, were isolated from lichens in Antarctica.

INTRODUCTION

Mycological studies in the Antarctic have so far been restricted to a large extent to soil (Bailey & Wynn-Williams 1982, Cameron 1971, Heal *et al.* 1967, Mercantini *et al.* 1989, Sun *et al.* 1978, Tubaki & Asano 1965) or freshwater habitats (Ellis-Evans 1985, Montemartini-Corte 1991, Sugiyama *et al.* 1967). Plants, mosses and animal material have been used as sources for isolation in several recent investigations of antarctic micromycetes (Baublis *et al.* 1991, Frate & Caretta 1990, Onofri & Tosi 1989, Pugh & Allsopp 1982). Lichens, well represented in the Antarctic (Smith 1984), are known as a substratum for a great variety of usually fairly specific fungi (numerous papers, summarized by Hawksworth 1979, 1982; Hawksworth *et al.* 1980; Clauzade *et al.* 1989; Petrini *et al.* 1990). The fungal colonization of antarctic lichens has been the subject of around 30 rather scattered observations (D.L. Hawksworth, pers. comm.), such as Vainio (1903), Spegazzini (1910), Pegler *et al.* (1980), Fletcher *et al.* (1985), Øvstedal & Hawksworth (1986), and Hawksworth (1991). Therefore it was decided to isolate fungi associated with different antarctic lichens. During the cruise AntX/1b of the German Research icebreaker ‘Polarstern’ to the Antarctic Peninsula in the austral summer season 1991/1992 collections of lichens were made and subsequently several interesting lichenicolous hyphomycetes were isolated, including two new species which are described in this paper.

MATERIAL AND METHODS

Lichen samples from rocks were collected with sterile instruments into sterile polyethylene tubes and processed within 24 h on board of the ‘Polarstern’.

Fragments of the lichen thalli were shaken in 50 ml sterile water, transferred to a sterile sieve and washed again with 500 ml sterile water. Then they were cut into pieces of approximatly 0.5–1 mm diam with a sterile scalpel, placed onto the surface of agar in petri dishes containing 5 g/l malt extract, 20 g/l agar and 10 ml filter-sterilized antibiotic solution (per 10 ml solution: bacitracin 0.02 g; tetracyclin 0.02 g; streptomycin 0.02 g; neomycin 0.02 g; polymyxin B 0.02 g; penicillin G 0.02 g) added after sterilization. The plates were incubated at 5°C or 10°C. After two weeks incubation all plates were transferred to a 1°C container, in which they remained for 4½ months during transport to Germany. Isolation of the fungi took place five months after processing the original samples.

The morphology of the fungi was observed on 2% malt (MEA) and potato-carrot (PCA) agars. Temperature relationships were established at 3, 6, 10, 15, 17.5, 20 and 24° C on 2% MEA.

Chaunopycnis ovalispora n. sp. — Fig. 1.

Coloniae lente crescentes, albae, tenues, floccosae, subinde granulosae. Hyphae vegetativae hyalinae, leves, tenuitunicatae, 1.0–2.0 μm latae. Conidiomata e mycelio aerio oriunda, globosa vel forma irregularia, 100–750 μm diam, pariete ex hyphis laxe intricatis composito circumdata. Phialides cylindricae, nonnumquam inflatae et in parte basilari ellipsoideae, abrupte in collulum saepe lateraliter insertum angustatae. Phialides 10–30 μm longae, ad basim 1.0–2.0 μm, ad apicem <0.5–1 μm latae, collari invisibili, cellula subterminali saepe collulo fertili praedita. Conidia forma variabilia, globosa, ovoidea, ellipsoidea, cylindrica, reniformia, clavata, hyalina, levia, 3.5–9 × 2.5–3.5 µm. Chlamydosporae absentes. Teleomorphosis ignota. Temperatura crescentiae optima 10–15°C, maxima 21°C.

Typus exsiccatus et vivus CBS 700.92, isolatus e *Caloplaca regali* (Vain.) Zahlbr., prope stationem Polonicam Arctowski in Insula Regis Georgii, Antarctica, Dec. 1991.

Colonies on MEA very slow-growing, reaching 6–8 mm diam after 14 d at 15–17.5°C, white, thin, floccose, becoming granular (after *c.* 4 weeks) due to conidioma formation. Vegetative hyphae hyaline, smooth-walled, 1.0–2.0 µm wide. Conidiomata formed in the aerial mycelium, globose or of irregular shape, 100–750 µm diam, wall composed of a loose hyphal weft. Sporulation occurring mainly in the conidiomata but also on the free mycelium. Phialides cylindrical, sometimes swollen and ellipsoidal in the lower part, narrowing abruptly into a thin neck that often arises in lateral

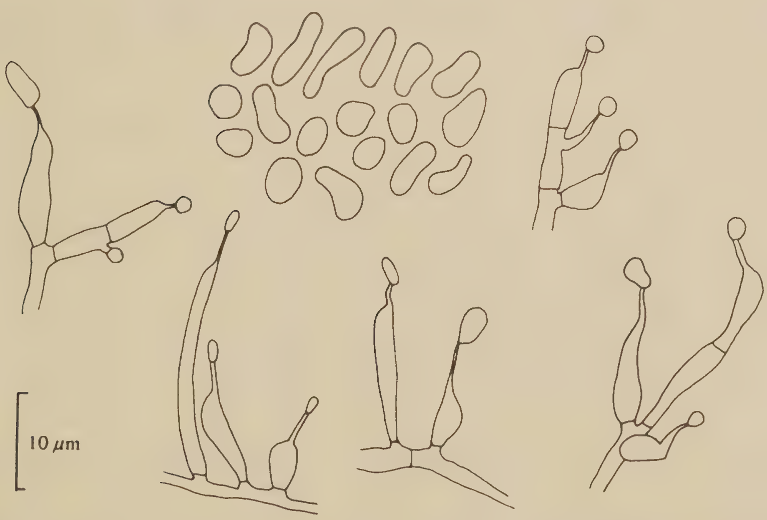

Fig. 1. *Chaunopycnis ovalispora*, conidiophores, phialides and conidia, CBS 700.92.

position. Phialides 10–30 μm long, 1.0–2.0 μm wide at the base, <0.5–1 μm wide at the tip, without signs of a collarette, subterminal cells often bearing a pleurogenous fertile neck (sesquiphialides) commonly formed; conidia variable in shape: globose, ovoid, ellipsoidal, cylindrical, reniform, clavate, ± tapering and truncate at the base; hyaline, smooth-walled, (3.5–)4.5–9 x 2.5–3.5 μm. Chlamydospores absent. Teleomorph unknown.

Ch. ovalispora sporulates well on MEA at 15°C, but much better on PCA. Cardinal temperatures for growth: minimum near 1°C, optimum (10–)15–17.5°C, maximum 21°C (1 week at 24°C was survived by one isolate).

MATERIAL EXAMINED: CBS 700.92 and 138.93, isolated from *Caloplaca regalis* (Vain.) Zahlbr., a crustose nitrophilic epilithic lichen, collected in a penguin colony near the Polish station Arctowski, King George Island, Dec. 1991.

Because of the loose conidioma wall and the tendency to sporulate with similar structures also on the free mycelium, *Chaunopycnis* takes an

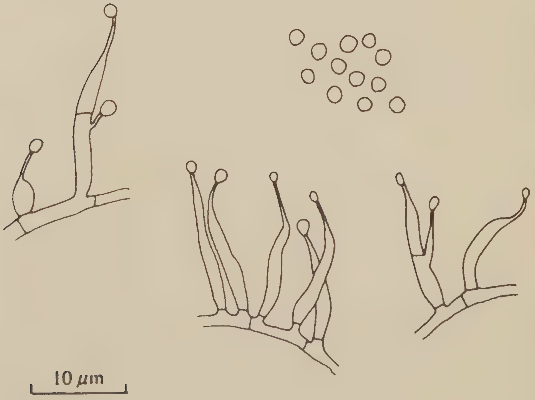

Fig. 2. *Chaunopycnis alba*, simple phialides and sesquiphialides, CBS 701.92.

intermediate position between the Hyphomycetes and the Coelomycetes. This observation holds for both species of the genus so far known. In the two isolates of *Ch. ovalispora* sesquiphialdes were quite often seen; this structure was not described by Gams (1980) for *Ch. alba*, but later observations have shown that this feature commonly occurs in both temperate and tropical isolates of this species too (Fig. 2).

Ch. ovalispora differs from *Ch. alba* mainly in the size and shape of the conidia and phialides. The conidia of *Ch. alba* are globose and 1.5–2.0 μm diam, while those of *Ch. ovalispora* are of variable shape and up to 9 μm long. Another typical feature contrasting *Ch. ovalispora* from *Ch. alba* is the abrupt narrowing of the phialides into the very thin lateral (or terminal) neck.

Apart from these morphological criteria, *Ch. ovalispora* also differs in the temperature relationships. *Ch. alba* was shown to have a worldwide distribution; for some isolates of *Ch. alba* the optimal growth temperature was observed by Gams (1980) to be 24–27°C; we have observed an optimum of 21–24°C for isolates from Antarctica (CBS 701.92) and Spitsbergen (CBS 702.92); *Ch. ovalispora* is not able to growth above 20°C.

Upon a suggestion by D.L. Hawksworth, we compared this fungus with the anamorph of *Caloplaca regalis* (sometimes segregated as *Polycauliona* Hue), of which A. Aptroot kindly provided some material (S. Kurokawa & H. Kashiwadani, Lichenes rariores et critici exsiccati 552, Chile, Magallanes; ex herb. BM, Antarctica, W. Graham Land, Port Lockroy, 'Discovery' Exped. 1934–35, no. 1489). The densely botryose conidiomata of the latter fungus have a firm wall of textura intricata; the short phialides densely line the irregular inner surface, and the conidia are clavate, 3.0–3.7 × 1.0–1.5 μm. Thus the two fungi are obviously not connected.

Acremonium psychrophilum n. sp. — Fig. 3.

Coloniae lente crescentes, cremeae vel albidae, mycelio aerio carentes, leves, madidae, tenaces. Sporulatio phalacrogena vel nematogena. Hyphae vegetativae hyalinae, leves, crassitunicatae, 1.0–2.0 μm latae. Conidiophora mononematosa, seu phialides simplices, seu conidiophora semel vel bis basitone ramosa. Phialides rectae vel modice curvatae, sursum attenuatae, leves vel granulosae incrustatae, crassitunicatae, collulum protrudens

minimum raro visibile, 20–70 μm longae, ad basim 1.8–2.8 μm latae, sursum ad 0.8–2.0 μm angustatae. Conidia capitulis mucidis adhaerentia, cylindrica, hyalina, levia, 5–13 × 2–2.5 μm. Chlamydosporae absentes. Teleomorphosis ignota. Temperatura crescentiae optima 10–15°C, maxima 21°C.

Typus exsiccatus et vivus CBS 732.92, isolatus ex *Turgidosculo complicatulo* (Nyl.) J. Kohlm. & E. Kohlm., prope Stationem Argentinam Jubany, in Insula Regis Georgii, Antarctica, Dec. 1991.

Colonies very slow-growing, after 14 d reaching 5–8 mm diam on MEA at 15°C, on PCA 8–12 mm, on MEA cream-coloured, on PCA whitish, with scant aerial mycelium, smooth, moist, tough. Sporulation phalacrogenous and nematogenous. Vegetative hyphae hyaline, smooth-walled, thick-walled (chondroid), 1.0–2.0 μm wide. Conidiophores mononematous, consisting of simple phialides or basitonously branched. Phialides straight or slightly

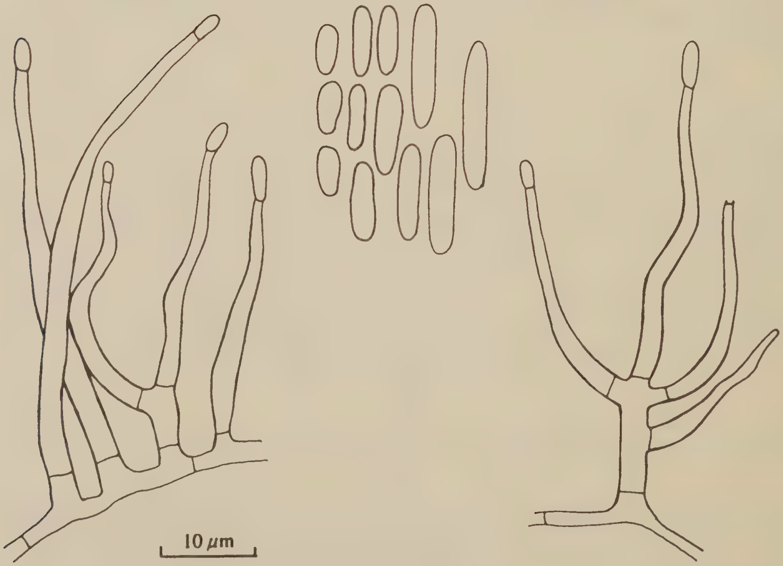

Fig. 3. *Acremonium psychrophilum*, conidiophores and conidia, CBS 732.92.

curved, tapering towards the apex, smooth-walled, seldom showing a short protruding collarette, thick-walled, 20–70 µm long, at the base 1.8–2.8 µm, at the tip 0.8–2.0 µm wide. Conidia adhering in slimy heads, cylindrical to ellipsoidal, hyaline, smooth-walled, 5–13.5 × 2–2.5 µm. Chlamydospores absent. Teleomorph unknown.

Cardinal temperatures for growth: minimum near 1°C, optimum (10–) 17.5(–20)°C, maximum 21°C (1 week at 24°C was not survived).

MATERIAL EXAMINED: CBS 732.92 and 139.93, isolated from *Turgidosculum complicatulum* (Nyl.) J. Kohlm. & E. Kohlm., a foliose epilithic lichen from a slope near the Argentinian station Jubany, King George Island, Antarctica, Dec. 1991.

Because of the chondroid hyphae, which render the colony very tough, and the thick-walled phialides, we classify *A. psychrophilum* in section *Gliomastix* (Guéguen) W. Gams of *Acremonium*. Among the hyaline species of this section it is close to *A. verruculosum* W. Gams & Veenbaas-Rijks, which was originally classified in sect. *Nectrioidea* (Gams, 1971) but shows also the above-mentioned features of sect. *Gliomastix; A. verruculosum* differs from *A. psychrophilum* by roughened, cyanophilic conidia, measuring 5.6–6 × 2.3–2.5 µm. There is no other described species in this section with comparable cylindrical conidia. By this feature *A. psychrophilum* shows some similarities with *A. strictum* W. Gams, but is distinguished by having larger conidia und wider and more thick-walled vegetative hyphae and phialides.

The known lichen-inhabiting *Acremonium* species, *A. antarcticum* (Speg. 1910) D. Hawksw. (1979), *A. lichenicola* W. Gams (1971), *A. rhabdosporum* W. Gams (1971), *A. spegazzinii* D. Hawksw. (based on *Verticillium lichenicola* Speg.) (Hawksworth, 1979), and the anamorph of *Pronectria santessonii* (Lowen & D. Hawksw. 1986) Lowen (1990) differ from the present species. *A. spegazzinii* is the closest but has verruculose phialides and smaller conidia (4–6 × 2–3 µm). The conidia of *A. rhabdosporum* possess an annular wall-thickening at either end and are longer. *A. lichenicola* has thin-walled hyphae, ochraceous–pinkish colonies, and does not have branched conidiophores; the conidia are often two-celled. *A. antarcticum*, a member of section *Acremonium*, was also described first from an Antarctic lichen, *'Teloschistes'* sp., but is now known also from material collected by G. Marson, Luxembourg, on *Hypogymnia physodes* (L.) Nyl. (CBS 987.87); it usually does not have branched conidiophores, and the phialides (15–20 μm) and conidia (4–5.5 × 1.5–2.5 μm) are shorter than in *A. psychrophilum.*

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Prof. D.L. Hawksworth kindly reviewed a draft of this paper and gave valuable additional information. Dr A. Aptroot provided anamorphic material of *Caloplaca regalis* and some more information.

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A NEW SPECIES OF *PLEUROTUS* FROM THE SAN FELIPE DESERT (BAJA CALIFORNIA, MEXICO)

by

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Abstract: *Pleurotus bajocalifornicus* Esteve-Raventós, Moreno & Ayala is proposed as a new species. Macro and microphotographs of its morphological characters are added.

Key words: *Pleurotus bajocalifornicus*, *Agaricales s. lato*, Baja California (México), taxonomy, chorology.

This is the first contribution on *Agaricales s. lato* from the mycological joint-research that is being conducted by mycologists from Baja California (México) and Alcalá de Henares (Madrid, Spain) Universities. Some results were published previously, mostly dealing with some taxonomic groups of *Gasteromycetes*, such as the genera *Tulostoma* and *Abstoma* (MORENO, ALTÉS & WRIGHT, 1992a, 1992b; MORENO, ALTÉS, OCHOA & WRIGHT, 1992). Additional contributions on some groups of *Agaricales*, *Helotiales* and *Myxomycetes* are being completed now.

The mycological research is mainly focused in Baja California Norte, especially in desert areas with abundant *Cactaceae*, areas of Chaparral vegetation, and conifer woodlands in the high Sierras (Sierra Juárez and San Pedro Mártir). It is in the desert areas where abundant collections of *Gasteromycetes s. lato* have been made, whereas agarics are practically absent here, except for *Pleurotus bajocalifornicus*, the only one registered. Agarics may be rather frequent in San Felipe district when precipitation favors their fructification; however, rainfall is not frequent in this territory and fructification periods are extremely short or do not happen at all. The San Felipe desert is the driest area on the Peninsula and has the highest evaporation rates.

The dominant plant species in San Felipe Desert are mainly Creosote Bush ("Gobernadora") and Bursage ("Huizapol"). Also common are Mesquite, Ocotillo, *Cactaceae spp.*, Palo Verde and Torote.

Though taxonomical and physiological studies about fungi from several xeric and ecologically similar areas have been carried out in Arizona (NAKASONE & GILBERTSON, 1978) and Chihuahua (LAFERRIÈRE & GILBERTSON, 1992), this is the first contribution about agarics from desert areas in Baja California. Very recently, DESJARDIN & al., 1992) described *Marasmius inaquosi* growing on palo verde (*Cercidium microphyllum* (Torr.) Rose & Stu) debris from the Sonora desert.

The *holotypus* has been deposited at the Herbarium of the Plant Biology Department at Alcalá de Henares University (AH) and isotypes have been deposited at the Herbarium of the Faculty of Sciences in Ensenada, Baja California (BCMEX) and the H.D. Thiers Herbarium at San Francisco State University (SFSU). Microphotographs have been made with a Labophot microscope with automatic photographic system, using Ilford 125 ASA film. The samples were observed in 5% KOH solution and distilled water using phase-contrast optics.

PLEUROTUS BAJOCALIFORNICUS Esteve-Raventós, Moreno & Ayala, spec. nov.

Pileus 1,5-5 cm diam., *convexus vel plano-convexus, albido puro vel albido-cremeo in maturitate. Laminae subdecurrentes vel decurrentes, albidae, cremeae in maturitate. Stipes* 3-6 x 0,5-1 cm, *curvatus vel sinuosus, bulbosus in basi* (-1,5 cm), *eundem colorem ac pileus habens. Epicutis hyphis cylindraceis, hyalinis, haud pigmentosis constituta. Basidia tetrasporica*, 40-55 x 7,5-10 µm. *Sporae cylindricae*, (10,5-)13-16,5(-18) x 5,5-7 µm, *hyalinae, haud dextrinoideae, haud cyanofilae, abundantibus granulis intus. Conidiogenae cellulae in acies lamellarum 40-50 x 6-9 µm, obtegentia, fusiformia, hyalina, apendice vel collo variabilibus quoad longitudinem.*

Species seiuncta vel raro glomerata, in Larrea tridentata proximitate. Desierto de San Felipe (Baja California Norte, Mexico). *Leg.*: C. Ochoa, N. Ayala, A. Altés, G. Moreno & F. Esteve-Raventós; 26-X-1991. ***Holotypus* AH 14575**.

Material studied: Isolated or in groups of two fruitbodies, partly buried in the sandy soil under the canopy and near the trunks of *Larrea tridentata* (also one collection under *Fouquieria splendens*); plains between Playa Grande and San Felipe town (Baja California Norte, Mexico); *leg.*: C. Ochoa, N. Ayala, A. Altés, G. Moreno & F. Esteve-Raventós; 26-X-1991. ***Holotypus* AH 14575.**

Pileus 1,5-5 cm diam., convex to plano-convex, not or hardly depressed, smooth, dry, somewhat pruinose near the edge, without veil, pure white to cream-whitish with ochraceous tints when old or dried; margin rounded, involute when young, then often undulate, fleshy (Fig. 1). Stem 3-6 x -1 cm, white, more or less central to slightly excentric, curved, cylindrical with a bulbose base that is buried in the sand (-1,5 cm), white- pruinose in its uppper third part. Lamellae shallowy decurrent, sometimes only arcuate or attached (like some Lepistas), crowded, whitish to ochraceous, not anastomosing near the stem, with powdery-white edge, somewhat cartilaginous, no hyphal pegs. Flesh thick, completely white, more or less cartilaginous, never coriaceous, not sclerotized at the bulbous stem base. Smell not recorded. Spore-print not recorded.

Spores (10,5-)13-16,5(-18) x 5,5-7 µm, hyaline, cylindrical, smooth, multi-guttulate, non-cyanophilous, non-amyloid (Figs. 5 and 6). Basidia 40-55 x 7,5-10 µm, long and slender, clavate, 4-spored, vacuolate (Fig. 4). Conidiogenous cells 40-50 x 6-9 µm, covering the entire gill-edge, sometimes present in the stipitipellis (upper half of the stipe),thin-walled, smooth, hyaline, with variable shape, regularly clavate or cylindrical or fusiform, with apical and long capitate processes, sometimes bi- or tri-furcate (Fig. 7). Cystidia not-observed. Subhymenium -20 µm wide, made up of thin and sinuous hyphae. Trama monomitic, formed by ramified and thin-walled hyphae, with clamps. Gill trama more or less interwoven, composed of hyphae 2,5-7 µm diam., clamped, easily detaching from the hymenium, somewhat gelatinized. Pileipellis a cutis with many elements with free ends, branched, without cystidia or coremia, the terminal cells more or less tapering, clamped (Figs. 2 and 3). Veil not present.

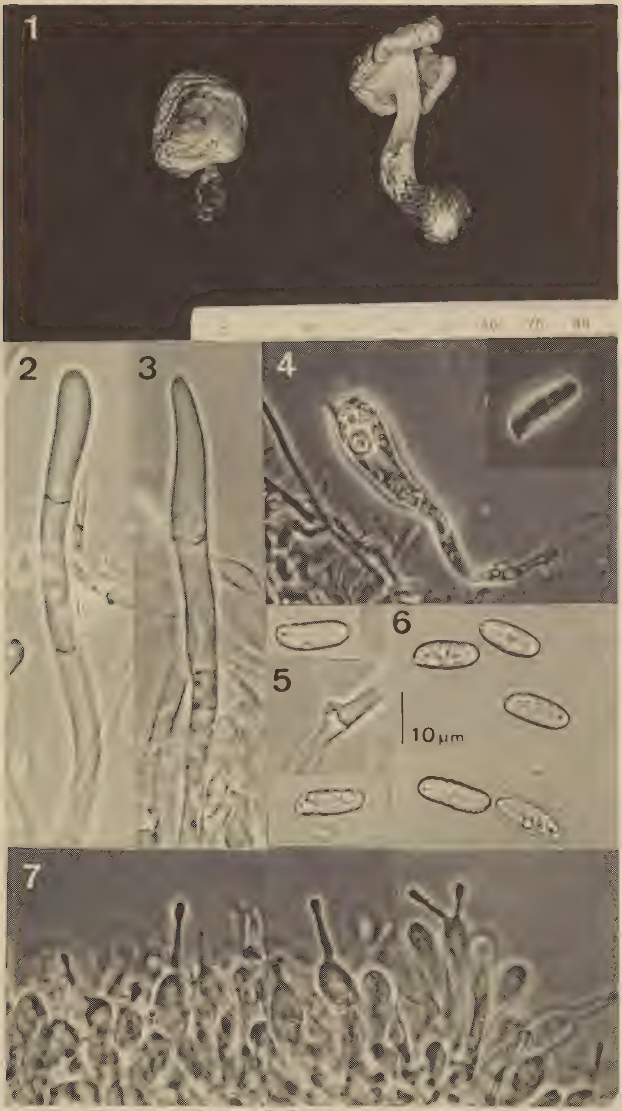
DISCUSSION

In spite of its "clitocyboid" or "lepistoid" habit, this new taxon clearly belongs to the genus *Pleurotus*. The trama, devoid either of skeletal or thick-walled generative hyphae, cylindrical spores, more or less irregular and gelatinized hymenophoral trama and the absence of metuloids, are indicative of a *Pleurotus* species.

Pleurotus bajocalifornicus is characterized by moderately small basidiomata, unpigmented throughout, shallowy decurrent lamellae, somewhat bulbose stem and, above all, its particular ecology. No veil has been observed in all stages of development, suggesting that the species is gymnocarpous.

According to CORNER (1981), the three genera *Lentinus*, *Panus* and *Pleurotus* can be separated according to the composition of the trama, with those species having monomitic trama considered exclusively as *Pleurotus*. None of the mostly tropical representatives studied by him fit the set of characters of the new species.

HILBER (1982) considers either monomitic or dimitic species in *Pleurotus*, *those monomitic in subgenera Coremiopleurotus* (with coremia and cystidia) and *Pleurotus p.p.*; dimitic species are considered by him in subgenera *Lentodiopsis* and *Pleurotus p.p. Pleurotus bajocalifornicus is a monomitic species, and though culture-tests have not been carried out, is seemingly included* in subgenus *Pleurotus, owing to the lack of true custidia in any part of the basidiomata. Neither coremia nor aleuriospores have been observed in our material. If we follow HILBER (loc. cit.)*, *P. eryngii* would seem to be the most related taxon, though differences in ecology, morphology, colors of the basidiomata and microscopic features are very relevant; *P. eryngii* is a well-known European species, commonly growing on *Umbelliferae* rotten roots, has a



Figs. 1-7. *Pleurotus bajocalifornicus sp. nov.*, *Typus*, AH 14575); 1: fruitbodies, 2-3: epicutis, 4-6: basidia, spores and clamped hyphae, 7: conidiogenous cells at gill-edge.

well-developed, normally eccentric stipe and a typically pleurotoid habit. Also, *P. kormanitzkyi* Vasilkov, *P. citrinopileatus* Sing. and those taxa of the *P. ostreatus/columbinus/pulmonarius* complex seem to be quite different from an ecological and morphological point of view.

Lastly, SINGER (1986:176) considers a separation between *Pleurotus*, *Lentinus* and *Panus* according to hymenophoral features. A well-developed sybhymenium is indicative of a *Pleurotus* species and not of *Panus*, in which the species are characterized by having a very inconspicuous or absent subhymenial layer. On the other hand, according to SINGER (1986), *Lentinus* shows a regular or subregular gill-trama, which is not present in *Pleurotus* and *Panus*, where it is more or less regular; also, the presence of metuloids has hardly any significance at a genus-level in the three genera.

Though more studies, mostly genetical, physiological and ecological, will be needed to further understand the biological behaviour of this species, the hypothesis that *Pleurotus bajocalifornicus* is probably bound, either saprophitically or parasitically, to some representatives of the Baja California desert bushes, should not be rejected. Its presence in similar ecologies in California or Arizona might be probable.

ACKNOWLEDGEMENTS

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The authors are also grateful and want to thank Drs. R.Singer and D.E.Desjardin for their invaluable comments, revision and correction of the manuscript.

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A NEW SUBGENUS OF *INOCYBE, LEPTOCYBE* FROM JAPAN

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SUMMARY

Inocybe subgenus, ***Leptocybe*** subg. nov. is proposed to accomodate ***Inocybe acutata*** T. Kobayashi & Nagasawa, sp. nov. and ***I.casimiri*** Velenovsky.

RESUME

La sous-genus *Leptocybe*, subg. nov. est décrit. Deux espèces lui sont attribuées : *Inocybe acutata* sp. nov. et *I.casimiri*.

INTRODUCTION

During taxonomic studies on the genus ***Inocybe*** in Japan, the author encountered several Inocybes apparently hitherto unknown in the Japanese literature. Some of them have been reported by the author (T. Kobayashi & R. Courtecuisse (1993), T. Kobayashi (in press)) as new species or new records from Japan. In this paper ***I.acutata*** T. Kobayashi & Nagasawa is proposed as a new species on the basis of the specimens from Tottori, western Japan and a detailed description of ***I.casimiri*** from Japan (Hokkaido) is presented. In addition, a new subgenus ***Leptocybe*** T. Kobayashi is proposed to accommodate the two species, which are unique in the combination of characters of the spores (not smooth but spiny in ***I.acutata*** and nodulose in ***I.casimiri***) and the cystidia (thin-walled in the both; metuloids absent) among the genus ***Inocybe***.

MATERIALS AND METHOD

All specimens cited in this paper are deposited in herbarium of the Tottori Mycological Institute (TMI), the Natural History Museum and Institute, Chiba (CBM-FB), the author's private herbarium (TAKK), Otsu, R.Courtecuisse's private herbarium (RC), Lille, France and Murata Herbarium (MURATA), Hokkaido, Japan.

The color terms used are those from Kornerup & Wanscher (1967).

For microscopic observations, dried specimens were dehydrated in 5% KOH solution or 10% NH_4OH solution. Length measures excluded apiculus and sterigmata for spores and basidia respectively.

Thin-walled, clavate to pyriform elements are called this paper paracystidia.

TAXONOMIC PART

Inocybe subgenus ***Leptocybe*** Takahito Kobayashi, subgenus nov.

Cystidiis (hymenialibus) tenuitunicatis; metuloideis nullis; sporis angularibus, nodulosis, echinulatis, stellatis.

Species typica : ***Inocybe acutata*** T. Kobayashi & Nagasawa

Pileus campanulate, convex, umbonate, fibrillose, smooth, squamulose, squarrose, often rimose to rimulose, sometimes scaly. Lamellae adnate, adnexed, sinuate, almost free, brown when mature. Stipe equal or bulbous, surface fibrillose, squamulose, squarrose. Cortina present or indistinct. Context white to brown. Spore print brown.

Cheilocystidia thin-walled. Pleurocystidia absent. Caulocystidia mostly present, thin-walled. Paracystidia thin-walled, often catenate. Metuloids absent. Spores angulate, nodulose, echinulate, stellate, yellowish brown to brown. Basidia almost hyaline or pale yellow, mostly 4-spored.

REMARKS : The distinguishing characters of this subgenus are the possession of angulate, nodulose, echinulate or stellate spores and the absence of metuloids.

The subgenus ***Leptocybe*** is almost identical with an unnamed new section proposed by Singer (1986) in the subgenus ***Inocybe*** as "Section 9.(Unnamed)", although species having stellate spores are excluded in the section. At the same time when he proposed the "Sect. 9, he suggested that "this section should eventually be recognized as a subgenus on equal standing as subgenus I." (viz., ***Inosperma*** Kühn.). His idea is accepted here with an emendation on the spore characters.

KEY TO THE SPECIES OF SUBG. *LEPTOCYBE* IN JAPAN

Spores spiny; Pileipellis a cutis.
-------------- 1. ***I.acutata***

Spores nodulose; Pileipellis a trichoderm.
-------------- 2. ***I.casimiri***

1. ***Inocybe acutata*** Takahito Kobayashi & Eiji Nagasawa, sp. nov.

Plate 1, Figs. 1 - 7.

Pileo -20 x -5 mm lato, conico-campanulato, dein convexo vel plano-convexo, acute papillato, umbrino, fibrilloso, subtiliter rimoso. Lamellis adnexis, brunneis, albo-fimbriata. Stipite 49-90 x 1-2 mm, subbulboso, pallido-brunneo, albo-fibrilloso. Carne pallido-brunnea.

Sporis 12-14.6 x 9.8-13 μm, spinosis, luteo-brunneis. Basidia 24-29 x 11-14 μm, tetra-sporica. Pleurocystidiis (metuloideis) nullis. Cheilocystidiis 36-55 x 12-20 μm, tenuitunicatis.

Holotypus: (TMI 16507).

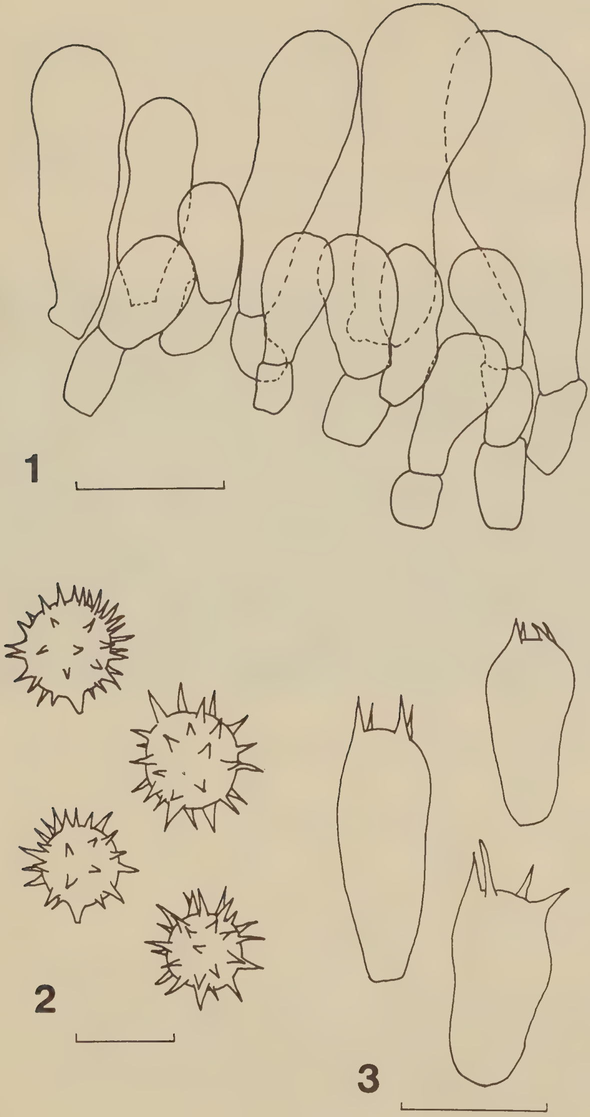
Pileus -20 x -5 mm, conico-campanulate at first, then convex to plano-convex, with acute papilla, with incurved then decurved margin, snuff brown (5F6) to burnt umber (6F6) with buffish papilla, surface fibrillose, rimulose, at times torn into scaly patches around the papilla when old, hygrophanous, translucent-striate almost up to center when wet, margin entire to crenulate (when old). Lamellae adnexed to almost free, moderately close, with 1 to 2 tiers of lamellulae, up to 3 mm broad, at first orange grey (5B2) to dull brownish orange (5C3), when old yellowish brown (5D5 to 5E5), edges whitish, fimbriate. Veil cortinoid, whitish, disappearing in early stage. Stipe 49-90 x 1-2 mm, slender, somewhat flexuous, often twisted when young, equal with slightly enlarged base (up to 4 mm), subbulbous, cartilaginous, fistulose when mature; surface striped, sheathed with whitish appressed fibrils except the very apex where subflocculose; ground color at first dull greyish orange (near 5B4), becoming brown (6E4 to 6E5) to dark brown (6F5) toward base. Context thin, buffish in pileus, pale brown in stipe. Odor indistinct. Taste mild. Spore print dark yellowish brown (near 5F3 to 5F4) when fresh, "Umber" when dry.

Spores 8.2-10.4 x 7.6-10.2 μm, 12-14.6 x 9.8-13 μm including spines, Q=1.0-1.3, subglobose, conspicuously spiny, yellowish brown, Basidia 24-29 x 11-14 μm, obovoid, almost hyaline to yellow (2A6, 3A6), 4-spored. Pleurocystidia absent. Paracystidia on side of lamellae catenate, total length -41 μm, rather abundant, thin-walled, the walls almost hyaline to slightly yellow, the terminal cells 16-26 x 9-14 μm, ellipsoid to narrowly clavate, sometimes with yellow (3A6, 3A7) to greyish yellow content (NH_4OH). Cheilocystidia 36-55 x 12-20 μm, clavate, sometimes with a median or apical constriction, thin-walled, rarely with light yellow (3A5) to vivid yellow (2A8) content (NH_4OH). Paracystidia on edge of lamellae abundant, catenate, total length -43 μm, thin-walled, terminal cells 16-23 x 8-11 μm, clavate to obovoid. Hymenophoral trama regular to subregular, of hyphae 4.4-8.0 μm in diam. Caulocystidia present only at the apex of stipe, 36-49 x 9-14 μm, narrowly clavate to sometimes apically constricted, thin-walled, rarely with yellowish brown content (NH_4OH), 36-49 x 10-14 μm, abundant, often in clusters. Paracystidia on apex of stipe rather scanty, often catenate, total length -43 μm, thin-walled, the terminal cells 13-25 x 7-11 μm, obovoid to cylindrical; on middle of stipe rather scanty, 18-22 x 9-11 μm, broadly clavate, obovoid, fusiform, rarely with yellow-brown content; on base of the stipe scanty, similar in morphology to those on the middle. Cotton hyphae 1.8-6.0 μm, almost hyaline, sometimes absent on apex of stipe; abundant on base. Pileipellis a cutis, up to 58 μm thick, subregular to regular, of hyphae 3.2-8.4 μm in diam, with yellowish brown to brown content (NH_4OH). Clamp connections present.

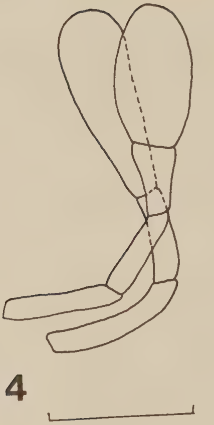
COLLECTIONS EXAMINED. - The oak garden of the Tottori Mycological Institute, Kokoge, Tottori-city, Tottori-pref., Under ***Quercus acutissima***, Jul.,3,1978, coll. Nagasawa, (TMI 12848 (=NAGASAWA 879)); Under ***Quercus*** spp., [Jun.,23,1981, coll. Nagasawa, (TMI 16507): holotype, ((CBM-FB 5260), (TAKK 2028-2)): Isotypes; Jun.,30,1981, coll. Nagasawa, (TMI 16509), (TAKK 2020); Jul.,12,1985, coll. Nagasawa, (TMI 16510)];

Ohro-yama, Ohro, Tottori-city, In mixed ***Pinus-Quercus*** woods, Sept,21,1978, coll. Nagasawa, (TMI 16511).

REMARKS : ***Inocybe acutata*** is characterized by the conspicuously spiny spores, the absence of metuloids, the dark



Figs. 1-3 ***Inocybe acutata*** T. Kobayashi & Nagasawa
1: Cheilocystidia, 2: Spores, 3: Basidia,
Scale bars: 1,3=20 μm; 2=10 μm.



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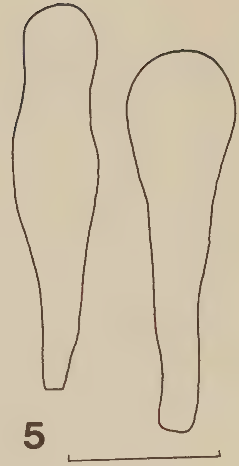

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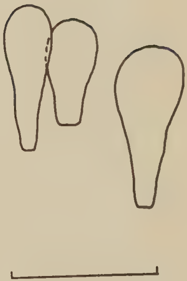

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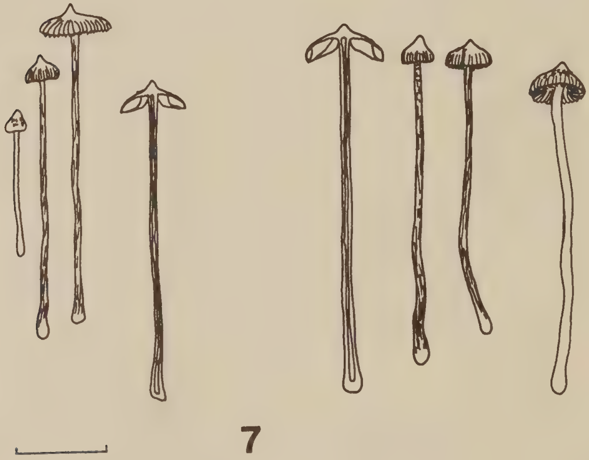

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Figs. 4-7 ***Inocybe acutata*** T. Kobayashi & Nagasawa
4: Paracystidia on side of lamellae, 5: Caulocystidia on apex of stipe, 6: Paracystidia on base of stipe, 7: Carpophores.
Scale bars: 4-6=20 μm; 7=2 cm.

brown, fibrillose pileus with an acute papilla, the slender subbulbous stipe sheathed with whitish appressed fibrils.

It seems most closest to ***Inocybe hydrocybiformis*** (Corner & Horak) Garrido from Singapore (Horak, 1979), but differs in the dark brown pileus, more slender habit, subbulbate stipe with a white-fibrillose surface.

I.calospora Quélet is somewhat similar due to the spore character, but can be easily separated by the thick-walled cystidia.

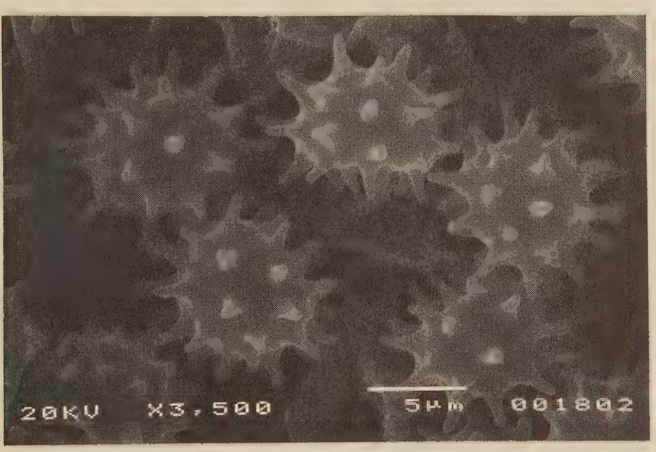


Plate 1. ***Inocybe acutata*** T. Kobayashi & Nagasawa Holotype spores (SEM).

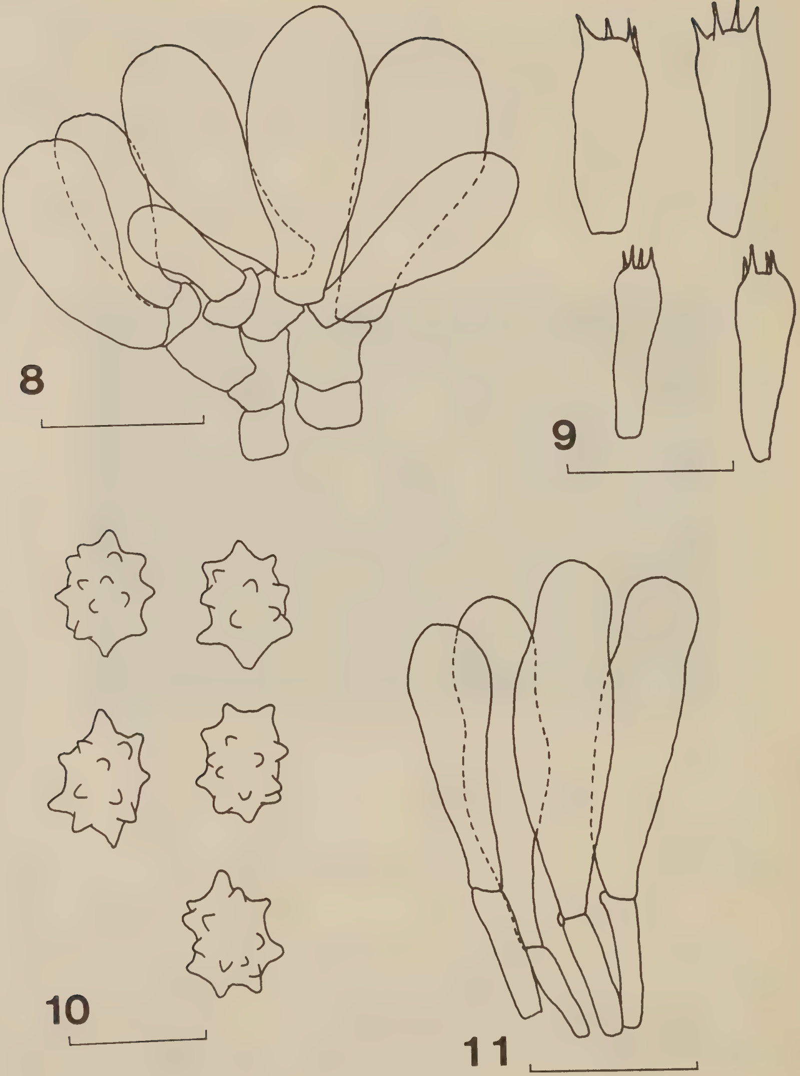
2. ***Inocybe casimiri*** Velenovsky, Ceské Houby 2: 369, 1920. fig.2 (A).

Figs. 8 - 13.

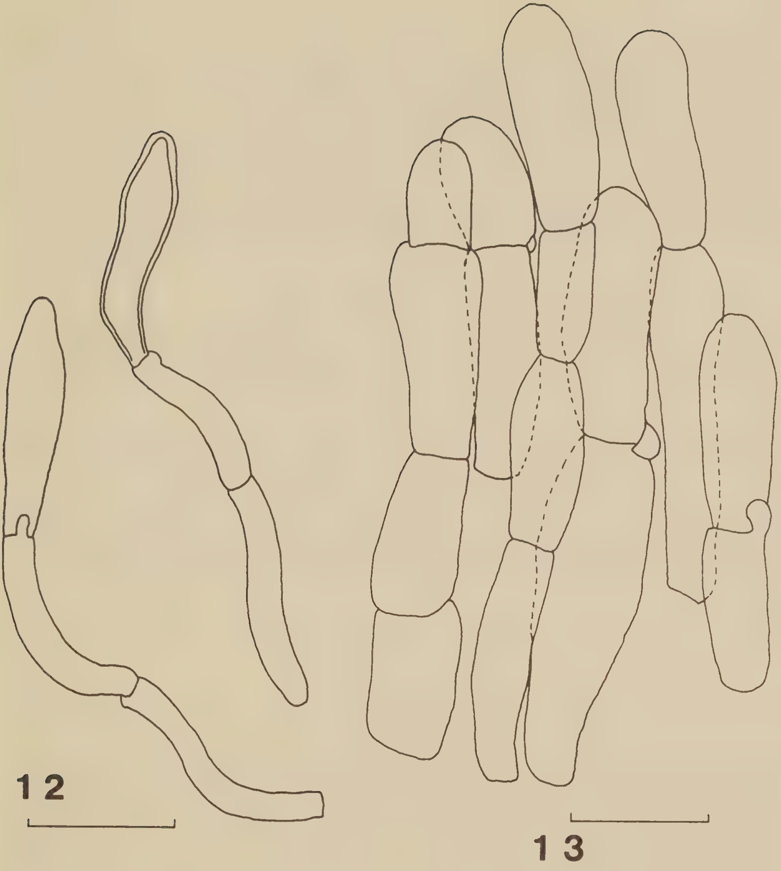
≡ ***Inocybe lanuginosa*** (Bull.: Fr.) Kummer var. ***casimiri*** (Vel.) Heim, Le Genre ***Inocybe***, 365, fig. 209, 1931.

≡ ***Astrosporina casimiri*** (Vel.) Horak, Arctic and alpine mycology II, 223, pl. 1, E; fig. 5, A-F, 1987.

Spores 9.2-12.2 x 6.8-9.4 µm, Q=1.2-1.6, nodulose, with small rounded knobs. Basidia 19-28 x 7-10 µm, narrowly clavate, 4-spored. Pleurocystidia absent. Cheilocystidia 19-36 x 8-13 µm, thin-walled, fusiform to clavate, sometimes narrowly utriform,



Figs.8-11 ***Inocybe casimiri*** Vel.
8: Cheilocystidia, 9: Basidia, 10: Spores, 11: Caulocystidia on apex of stipe.
Scale bars: 8-9,11=20 µm; 10=10 µm.



Figs. 12-13 *Inocybe casimiri* Vel.
12: Tomentose hyphae on surface of stipe, 13: Cuticle.
Scale bars: 12,13=20 μm.

almost hyaline to slightly yellowish in KOH. Caulocystidia clustered on apex of stipe, rather abundant, (11-)20-37 x 8-16 μm, thin-walled, clavate to narrowly utriform with a short pedicel, almost hyaline in KOH. Surface of stipe covered with tomentose hyphae, brown, superficial cells up to 8.8 μm in diam, sometimes with thickened walls. Cotton hyphae 2.6-3.4 μm, almost hyaline. Pileipellis a trichoderm, of hyphae 4.8-14(-22) μm in diam, encrusted with yellow-brown pigment. Clamp connections present.

COLLECTION EXAMINED - Shintoku-cho, Hokkaido, On the decayed stump of ***Quercus mongolica*** var. ***grosseserrata***, at the experiment stand in Eastern Branch of Hokkaido Forest Experiment Station, Aug.,12,1974, (MURATA 1273).

REMARKS : The characters of the Japanese material coincide with those of ***I.casimiri*** described by Velenovsky (1920) and of the Holland material (Terschelling, Oct.,25,1982, RC 82.10.25.30), although the latter specimen had somewhat more gibbose spores.

Inocybe casimiri resembles ***I.lanuginosa*** var. ***lanuginosa*** in appearance, but lacks pleurocystidia and has smaller nodules of spores.

First record of ***I.casimiri*** in Japan was given by Murata (1978).

DISCUSSION

The ideas about a infrageneric taxonomy of the genus ***Inocybe*** have been variously reported. Kühner (1980) split genus ***Inocybe*** into two subgenera based on characters of cystidia, viz. subgenus ***Inosperma*** Kühner and subgenus ***Inocybe*** in his sense. Kühner (1980) recognized a monophyletic group which had smooth spores and lacked metuloids, and he assigned species of this group to subgenus ***Inosperma***. Species with metuloids or gibbose spores were assigned to subgenus ***Inocybe*** in his sense.

Singer (1986) recognized three subgenera, viz. ***Inosperma***, ***Inocibium*** and ***Inocybe***. In this idea, smooth-spored species of genus ***Inocybe*** were split into two subgenera; ***Inosperma*** and ***Inocibium***. Subgenus ***Inocibium*** is characterized by metuloids and smooth spores, while all species with angulate to echinulate spores are assigned to subgenus ***Inocybe***. Fungus belonging to subgenus ***Inocybe*** in his sense have metuloids or thin-walled cystidia.

The systematic positions of species with thin-walled cystidia and gibbose spores have not been clearly discussed by the above-mentioned authors. The present author establishes subgenus

Leptocybe T.Kobayashi for species with angulate to echinulate spores and lacking metuloids. This idea splits subgenus *Inocybe* in Singer (1986) into two subgenera based on characters of cystidia, viz. subgenus *Leptocybe* and subgenus *Inocybe* in his sense. Thin-walled cystidia of *Leptocybe* present on edge of lamellae and apex of stipe only. The metuloids are observed from side and edge of lamellae and apex of stipe, and sometimes observed from base of stipe also.

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STUDIES ON KERATINOPHILIC FUNGI. I.
A NEW *MALBRANCHEA* FROM SULAWESI

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ABSTRACT

Malbranchea sclerotica Guarro, Gené & De Vroey **sp. nov.** was isolated from poultry farm soil in Sulawesi (Asia). Its main feature is the formation of numerous sclerotia.

INTRODUCTION

In the course of the examination of numerous keratinophilic fungi deposited at the Institute of Tropical Medicine 'Prince Leopold' of Antwerpen (Belgium), we have studied some interesting strains of ***Malbranchea***. One of them has several characteristics which differentiate it from the known species of the genus and is thus described here as new.

TAXONOMY

Malbranchea sclerotica Guarro, Gené & De Vroey **sp.nov.**

Coloniae in agaro PYE ad 25 °C lente crescunt, 19-20 mm diametri post 21 dies, albae vel cremeae, deinde castaneae, in medio gossypinae et elevatae, in margine floccosae, striae radiatae paulo signatae, margo leviter undulatus; reversum fuscum. Coloniae ad 37 °C lente crescunt, 17-18 mm diametri post 21 dies, in medio griseae, in margine albae, reversum griseo-fuscum propter productionem pigmenti diffusilis. Hyphae vegetativae hyalinae, 1.2-3 µm diametri, septatae, laeves, tenuitunicatae, frequenter deinde inflatae, crassitunicatae, brunneae, et formant sclerotia; sclerotia globosa, *subglobosa vel forma irregulari, usque ad 180 μm diametri, textura angulari vel epidermoidea, cum cellulis 5.5-15 μm diametri, laevibus et crassitunicatis. Arthroconidia ex ramulis lateralibus oriunda, cylindrica aut doliiformia, nonnumquam curva, subhyalina, laevia, 3.5-6.5 x 2-3.5 μm. Arthroconidia ex hyphis principalibus, cylindrica, subhyalina, laevia, 5.5-8 x 1.5-3.5 μm.*

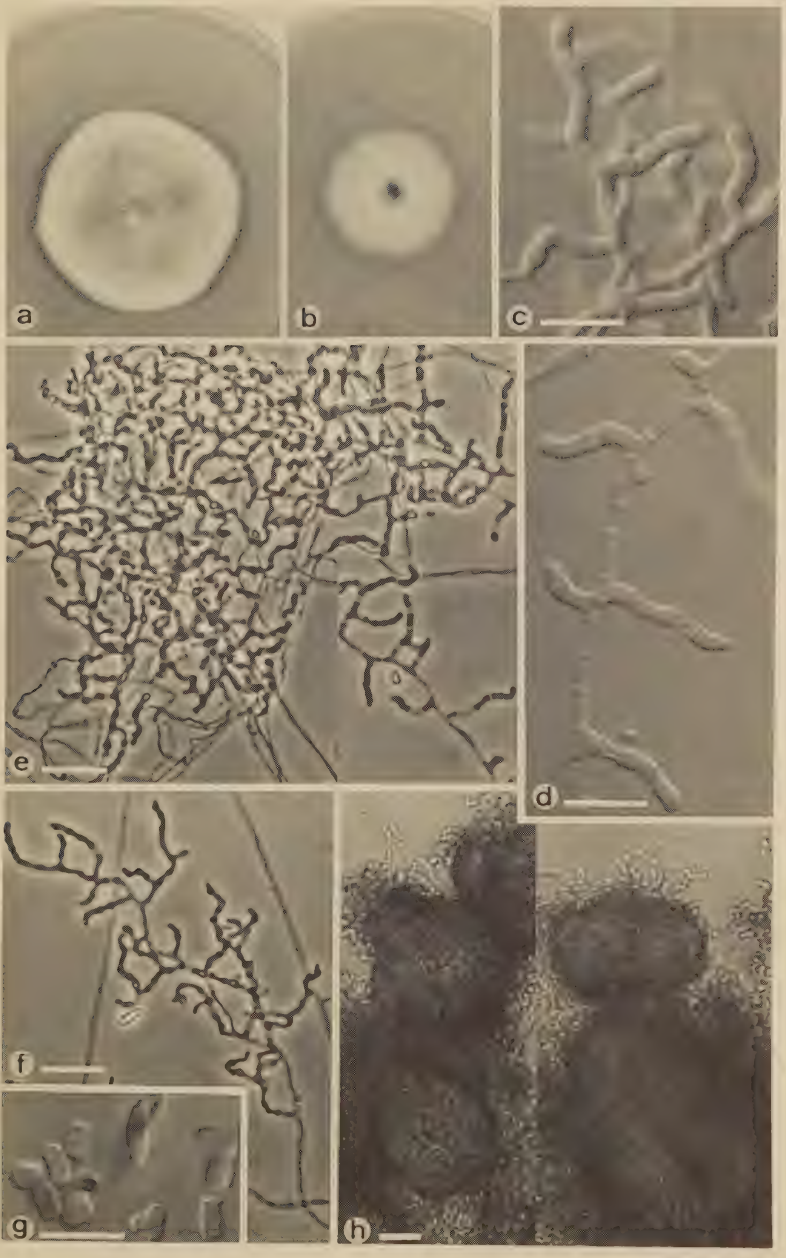
Typus: IMI 356293, *ex solo*, Sulawesi, 9 Aug. 1968.

Colonies on phytone yeast extract (PYE) at 25°C slow growing, 19-20 mm diam in 21 days, white to cream-coloured, becoming pale brown, raised, with white cottony central umbo, often with radial folds irregular, floccose at the periphery, margin slightly undulate and well defined, reverse dark brown, with exudate droplets in age. Vegetative hyphae hyaline, 1.2-3 μm wide, smooth, thin-walled, very often in some regions becoming swollen, pale brown and thick-walled, coalescing to form pseudoparenchymatous aggregations with the appearance of a solid tissue (sclerotia). Fertile hyphae arise as lateral branches, arcuate and branching repeatedly to form dense clusters. Arthroconidia cylindrical or barrel-shaped, sometimes curved, subhyaline, smooth-walled, 3.5-6.5 x 2-3.5 μm. Arthroconidia formed on the straight primary hyphae, cylindrical, subhyaline, smooth-walled, 5.5-8 x 1.5-3.5 μm. Racket hyphae absent. Sclerotia numerous, produced within 1-3 weeks and scattered over the entire colony surface, spherical to subspherical, often irregularly-shaped, brownish, up to 180 μm diam, with a wall of '*textura angularis*' to '*epidermoidea*', composed of thick-walled, 5.5-15 μm broad cells.

At 37°C the colonies are 17-18 mm diam in 21 days, white, pale grey in the centre, reverse dark greyish-brown with dark diffuse pigment, the rest of the features being similar.

On oat-meal agar (OMA) at 25°C colonies reaching 28-30 mm diam in 21 days, white, cottony to granulose, slightly funiculose, margin well defined and slightly fimbriate, reverse dark brown.

Fig. 1. a-g. ***Malbranchea sclerotica*** IMI 356293. a,b. Colonial morphology after 5 weeks at 25°C (a. on PYE; b. on OMA); c,d,f. Fertile hyphae (c,d. bar=10 μm; f. bar=20 μm); e. Cluster of fertile hyphae (bar=20 μm); g. Arthroconidia (bar=10 μm); h. Sclerotia (bar=25 μm).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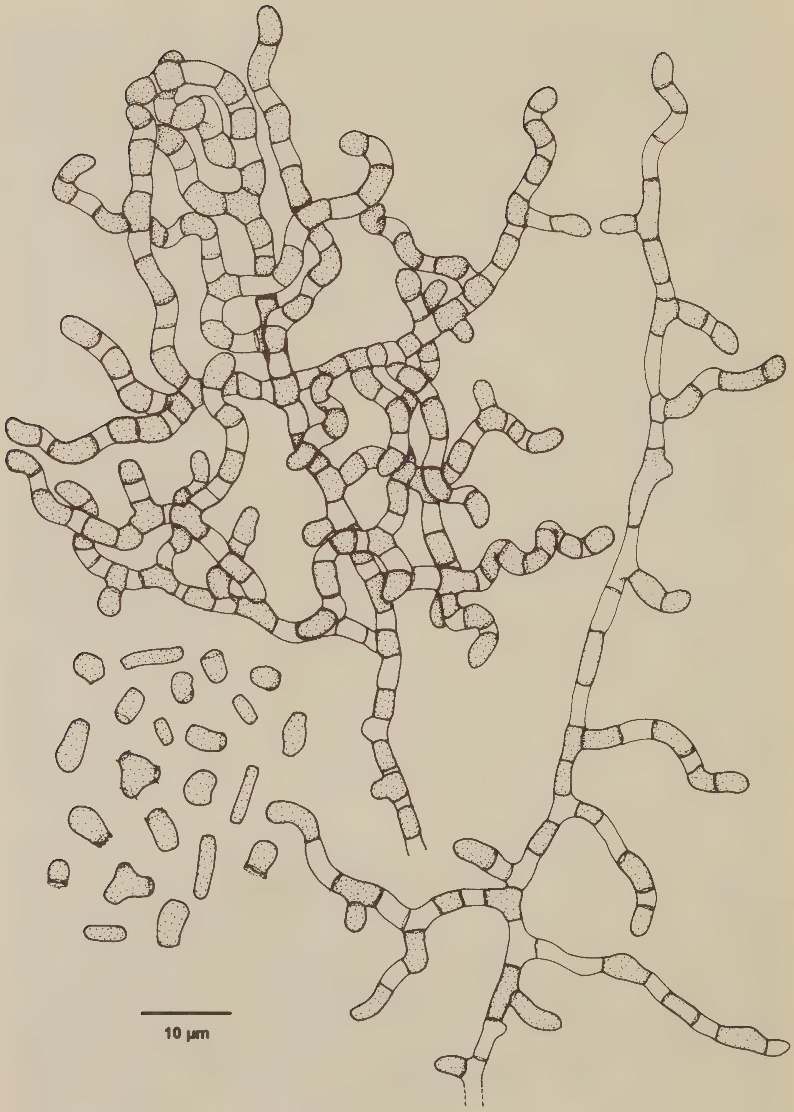

Fig. 2. ***Malbranchea sclerotica*** IMI 356293. Fertile hyphae and arthroconidia.

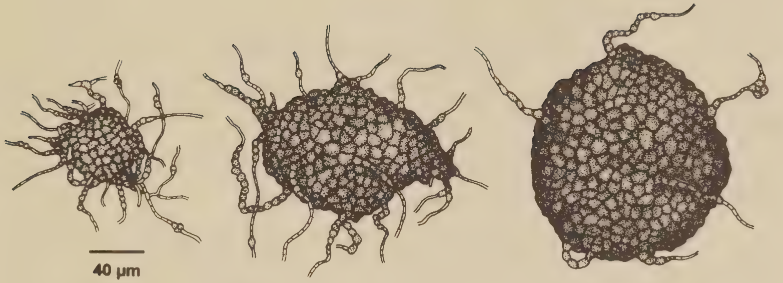

Fig. 3. ***Malbranchea sclerotica*** IMI 356293. Sclerotia.

Holotype: IMI 356293, isolated in Antwerp with the spray technique of Orr (Kuehn *et al.*, 1961) from a soil sample in a poultry farm, Sulawesi, 9 Aug. 1968. Isotypes: CBS 201.92, FMR 3853, RV 24857.

The formation of sclerotia observed in ***M. sclerotica*** is unique in this genus (Sigler & Carmichael, 1976). Some ***Malbranchea*** species are anamorphs of the Eurotiales but ascomata usually have a prosenchymatous peridium. Ascomata with a pseudoparenchymic peridium with flattened cells similar to the sclerotia observed here are rarely associated with ***Malbranchea***, with the exception of those of ***Aphanoascus*** (Cano & Guarro, 1990). These bodies were observed on the media tested (PYE, PDA, OMA and Sabouraud diluted 1/10 + salts) and asci and ascospores have never been observed inside them. The association of these structures with the ***Malbranchea*** conidia was proven repeatedly from monoconidial cultures. In ***M. filamentosa*** Sigler & Carmichael (Sigler *et al.*, 1982), associated appendages, similar to the hyphal wall of the ascomata but sterile, have also been reported. ***M. arcuata*** Sigler & Carmichael has some resemblance with ***M. sclerotica*** but does not usually grow at 37°C, and clusters of fertile hyphae and sclerotia are lacking.

ACKNOWLEDGEMENTS

The authors are indebted to Dr. E. Descals (C.S.I.C.) for correcting the English text and helpful comments and to Dr. J.M. Escola (Universitat Rovira i Virgili) for reviewing the Latin diagnosis.

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STUDIES IN MARASMIOID FUNGI - IX.
MARASMIUS HIGHLANDSENSIS, A NEW SPECIES IN SECT. MARASMIUS

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Abstract

A new species, *Marasmius highlandsensis* Antonín belonging to the sect. *Marasmius*, subsect. *Sicciformes* is described from the Blue Ridge Mts. (North Carolina, U.S.A.)

During my stay at the Biological Station in Highlands (U.S.A., North Carolina, Blue Ridge Mts.), I collected an interesting small collariate *Marasmius* species. It is macroscopically similar to *Marasmius octifolius* Murrill but differs in its microfeatures, and is described here as a new species. Colour terms are those of Kornerup & Vanscher (1978). Microscopical features are described from material mounted in Melzer's reagent, Congo-red, and NH_4OH. In a study of basidiospores, the following factors were used: x (the arithmetic means of the spore length and width); E (the quotient of length and wide in any one spore); Q (mean of E-values).

Marasmius highlandsensis Antonín sp. nov.

Pileus 2,5-3,5 mm latus, convexus, centro papillatus, sulcatus, centro obscure brunnescens, marginem versus pallescens. Lamellae collariatae, distantes (L = 11-12), albae, acie marginem pilei versus brunneae (id est pileo concolore). Stipes 11-18 mm longus, filiformis, laevis, stramineus, luteobrunneus, basim versus usque obscure brunneus. Basidiosporae 7,6-9,2 x 4,2-4,8 µm, ellipsoideae. Cheilocystidia biformia: 1) clavata, forma cellulis No. I pileipellis similia, 8,8-14,0 x 4,4-6,8(-8,8) µm et 2) marginem pilei versus irregulariter clavata (similia cellulis No. II pileipellis). Hyphae dextrinoideae, fibulatae. Pileipellis hymeniformis, e duobus typis cellularum constitua: typus I. sunt cellulae similes cellulis pileipellidis Marasmii sicci, clavatae, apice diverticulis, 10,0-22,4 x 6,4-12,0 µm; typus II. sunt cellulae irregulariter clavate vel lobate, (10,8-)16,0-27,2 x 4,4-9,2(-16,4) µm, crassotunicatae, brunneae. Cellulae intermediae duobus typis immixtae adsunt.

Hab.: ad aciculas Pini et ad reliquias plantarum emortuarum.

Holotypus: USA, North Carolina, Blue Ridge Mts., Blue Valley prope Highlands, 9. VII. 1991 leg. V. Antonin, in herbario mycologico TENN asservatur.

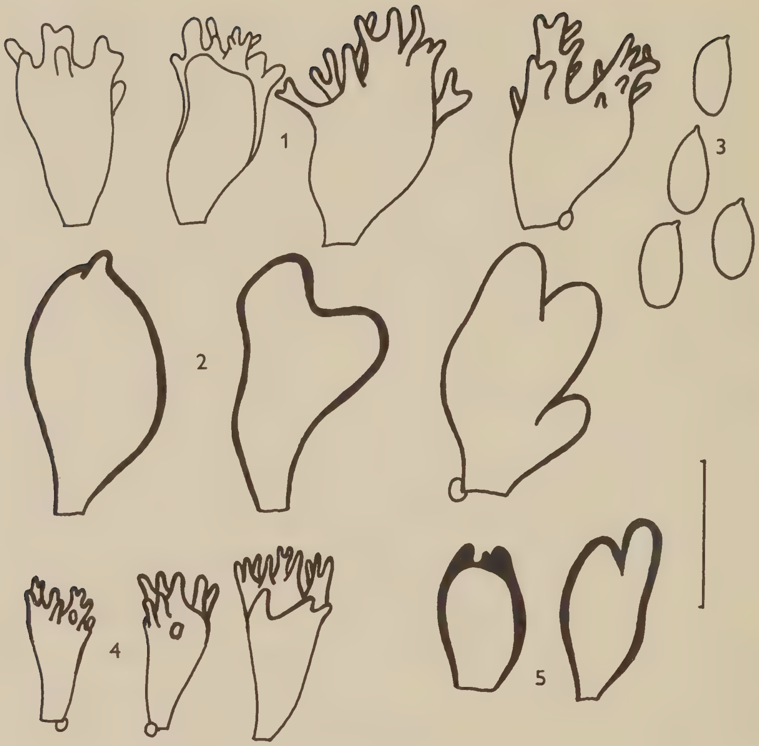
Pileus 2.5-3.5 mm broad, convex, with a distinct papilla at center, radially sulcate, crenulate on margin, slightly subvelutinous under lens; violet brown (10F6 to 10F7, 10E7) at center, pallescent through brown-red to whitish towards the margin. Lamellae collariate, collarium less distinct when fresh, distant, L = 11-12, without lamellulae, white, edge concolorous or slightly brownish near the pileus margin. Stipe 11-18 mm long, filiform, smooth, glabrous, shining (especially on the lower part), insititious, base slightly broadened; almost entirely greyish-orange, caramel brown (between 6B6 and 6C6), brown

to henna brown(7E7 to 7E8) only at base. Rhizomorphs not found.

Basidiospores 7.6-9.2 x 4.2-4.8 µm, x = 8.3 x 4.4 µm, E = 1.6-2.1, Q = 1.9, ellipsoid, thin-walled, hyaline, smooth, non-dextrinoid. Basidia 4-spored, clavate. Basidioles 10.4- 24.0(-26.4) x 3.2-7.6 µm, clavate to cylindrical, sometimes slightly fusoid, clamped, thin-walled. Cheilocystidia in shape of broom cells, 8.8-14.0 x 4.4-6.8(-8.8) µm, clavate, non-dextrinoid, hyaline, thin-walled, projections 3.2-6.0 x 1.2-1.8 µm, obtuse, sometimes branched, cylindrical, thin- walled and hyaline, except for those near the pileus margin which are slightly thick-walled and brownish; clavate cells similar to pileus broom cells of type-2 present on edge of the collarium. Pleurocystidia absent. Hyphae weakly dextrinoid to dextrinoid, clamped, cylindrical, sometimes branched, thin-walled and hyaline, except for those of the stipe cortex that are slightly thick-walled and brown pigmented, up to 10.8 µm broad. Caulocystidia absent. Pileipellis hymeniform, composed of two types of cells: 1) clavate broom cells of the Siccus-type, 10.0-22.4 x 6.4-12.0 µm, hyaline and thin-walled at base, thin- to slightly thick-walled and brown above; projections 3.2-7.2 x 1.6-2.8 um, obtuse, sometimes branched; 2) irregularly clavate to lobate cells, (10.8-)16.0-27.2 x 4.4-9.2(-16.4) µm, thick- walled (walls up to 2.4 µm), sometimes with some projections above, brown; both types mixed with cells intermediate in morphology. Cells of type-1 and intermediate cells are dominant mostly on pileus margin, cells of type-2 are most common on the pileus disc.

Growing on *Pinus* needles and remnants of grasses on a marshy bank of a small river, in a dense growth of plants.

Holotype: U.S.A., North Carolina, Blue Ridge Mts., Blue Valley near Highlands, 9. VII. 1991 leg. V. Antonin (TENN).



Figs. 1-5. *Marasmius highlandsensis* (holotype): 1. pileipellis cells of type-1; 2. pileipellis cells of type-2; 3. basidiospores; 4. cheilocystidia; 5. cells on edge of the collarium. Scale bar = 20 µm.

Marasmius highlandsensis belongs in subsect. *Sicciformes* Antonín (Antonín 1991) of sect. *Marasmius*. It is characterized by the following combination of features: 1) very small pileus with a distinct papilla; 2) pileus dark at center, pallescent towards the margin; 3) greyish-orange to caramel brown stipe; 4) two types of pileipellis cells with an intermediate form; 5) different types of cheilocystidia on lamellar and collarium edges.

Phenetically similar taxa include the following: *Marasmius inundabilis* Sing. differs especially in having larger pileus (4-6 mm), black stipe, longer basidiospores (14.5-18.5 µm), closer lamellae with their edges becoming black during drying (Singer 1989). *Marasmius iodactylus* Sing. has lilac-purple coloured, very small (0.5-0.8 mm) pileus, and smaller basidiospores (6-7.5 x 2.5-3.3 µm) (Singer 1989; holotype not sent for revision from INPA). *Marasmius trichorhizus* var. *aripoensis* Dennis is also characterized by two types of pileipellis cells, but differs in having darker coloured pileus, more distant lamellae (L = 8), and narrower basidiospores (x 3.2-3.8 µm) (Dennis 1951a; Holotype K!). *Marasmius chrysochaetes* Berk. et Curt. from Cuba is macroscopically similar but differs by more distant lamellae (L= 8-9), more numerous irregular-lobate and branched cells in the pileipellis, larger basidiospores (8.2-10.4 x 3.8-4.7 µm), and cheilocystidia similar to the pileipellis cells (Berkeley & Curtis 1869; Dennis 1951b; Holotype K!). According to Singer (1989), *Marasmius peckii* Murrill appears to be allied with this group of taxa. However, Murrill (in Pennington 1915) described a whitish to gray coloured pileus, blackish stem, and more distant lamellae (L = 8). Moreover, Singer (1976) did not mention any dimorphic cells in the pileipellis of *M. peckii*. Peck's type specimen (NY) has not been sent to me for a revision. *Marasmius octifolius* Murrill differs macroscopically in having a black stipe and only one type of cell on the lamellar edge and in the pileipellis. See Desjardin (1989) for a type study.

Acknowledgments

I wish to thank to the Hesler Endowment Fund for enabling me to stay at the University of Tennessee in Knoxville, and to study the Southern-Appalachian *Marasmius*-species. My thanks are due also to the curator of the Herbarium of the Royal Botanic Gardens in Kew (K) for facilitating the loan of type specimens, to Dr. Dennis E. Desjardin (San Francisco State University, U.S.A.) for valuable notes and correction of my English manuscript, and to Dr. Josef Herink (Mnichovo Hradiště, Czechoslovakia) for correction of my Latin diagnosis.

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BIOLOGY AND DESCRIPTION OF *USTILAGO LYGINIAE* SP. NOV., A NEW CULM SMUT ON *LYGINIA BARBATA* (RESTIONACEAE) IN WESTERN AUSTRALIA

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This publication comprises the first record of a new smut, *Ustilago lyginiae* sp. nov., on the vegetative parts of culms of the southern hemisphere rush *Lyginia barbata* (Restionaceae). The smut is readily distinguishable on sorus and teliospore morphology and host specialization. Stages in sorus development and teliospore germination are described.

INTRODUCTION

Vanky (1985, 1990) considers the culm smuts of Gramineae a taxonomically heterogeneous group parasitizing many genera of grasses. Based on a combination of characters including location of sori, presence or absence of a peridium, spore size, wall ornamentation and polar caps, Vanky (1985,1990) recognised six species in the genus *Ustilago* causing culm smuts of Gramineae.

In April 1992 an *Ustilago*-type smut was discovered on the culms of *Lyginia barbata* R. Br. (Restionaceae). There are no previous records of smuts parasitising vegetative parts of Restionaceae and floral parts of members of this family have not previously been recorded as hosts for *Ustilago* species.

The south-west Australian genus *Lyginia* (Restionaceae)currently contains a single species *L. barbata* in which Briggs (in Bell & Pate,1993) has tentatively recognized two forms or varieties, assigned 'in edit' names *L. barbata* var. *imberbis* and *L. barbata* var. *barbata.* According to Bell and Pate (1993) the *L. barbata* complex comprises five distinct morphotypes and smutted culms have been found on three of these.

This paper provides a description of the new smut in terms of infection characteristics, sorus development, teliospore structure and stages in teliospore germination.

MATERIALS AND METHODS

Culm smutted host material was collected from natural stands in open *Banksia* woodland in Gosnells, located in the Perth metropolitan area, in April 1992. Whole plants were recovered, potted and maintained in a glasshouse for analysis of freshly smutted material.

Observations on infected host culms

Photographs and detailed notes were taken of smutted and non-smutted host culms in natural sites to record the symptoms of infection.

Glycol methacrylate (GMA) resin sections were carried out to study smut sporulation and soral development on host culms (using techniques as outlined in O'Brien & McCully, 1981). Transverse sections (1-2 µm) of sori in different stages of development were taken using a Sorvall JB-4 Microtome and placed in a drop of deionised water on a glass slide. Sections were dried on a warming plate and stained by flooding with toluidine blue (pH 4.4) for a few seconds. For PAS staining, slides were placed in di-nitrophenylhydrazine in a Coplin jar for 30 minutes, rinsed under running tap water for 10 minutes and then placed in periodic acid for 10 minutes. Schiff's reagent replaced the periodic acid for 15 minutes after which slides were again rinsed in running water for 10 minutes. Slides were then air dried and counterstained with toluidine blue pH 4.4 for 30 seconds. After staining, all slides were dried on a warming plate and mounted in paraffin oil for microscopic examination. Photographs of sections were taken using a Wild Photomacroskop M400 and a Zeiss Axiophot.

Observations on teliospores

Fresh smut sori were examined using light microscopy (LM) and scanning electron microscopy (SEM).

Teliospores were observed using LM at 400X magnification in a drop of lactophenol cotton blue mountant. Slight pressure was applied to the slide coverslip to disperse sori for teliospore and spore-ball observations. Teliospore colour was observed in water.

Spore ornamentation and spore-ball conformation were observed under SEM. Sections of smutted culms were fixed in 5% gluteraldehyde in phosphate buffer, pH 7, for 24 h, with one vacuum infiltration for 1 h and one solution change. Samples were then washed twice in a 1:1 solution of phosphate buffer (Na_2HPO_4 (7.1 g/L) and NaH_2PO_4 (3.8 g/L)), followed by two washes in 100% ethanol for 24 h and two further washes, 12 h each, in acetone. Samples were then critical point dried in a CO_2 vacuum chamber after which culms were dissected to remove the smut sorus. The smut samples were then applied to double sided adhesive tape mounted on SEM specimen stubs, coated with gold under vacuum and examined with a Phillips Scanning Electron Microscope 505.

Observations on germination

For germination, fresh teliospores were dispersed onto slides coated with 15% water agar, supported on paper-clips and placed in a Petri plate lined with moistened filter paper. Plates were incubated at 24°C and examined after 4, 8 and 12 days under a light microscope after applying a drop of lactophenol cotton blue and a coverslip. Drawings of germinating teliospores were done at 1000 x using camera lucida.

RESULTS

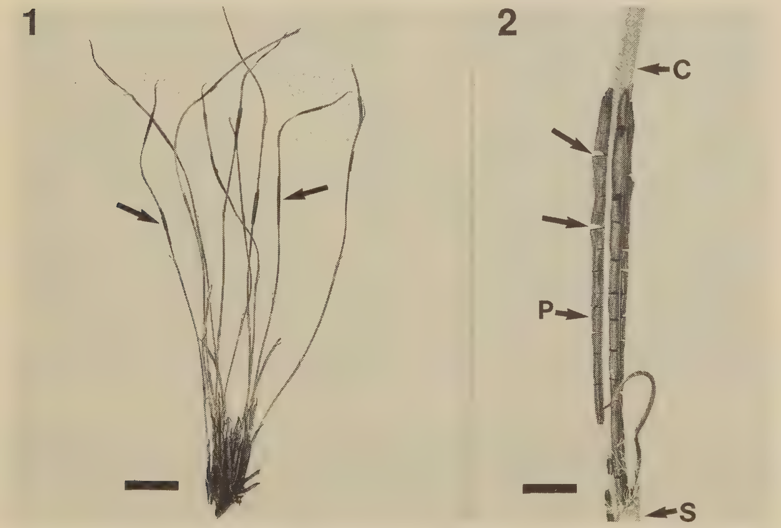
Ustilago lyginiae Websdane, Sivasithamparam, Dixon & Pate, *sp. nov.*

Type on *Lyginia barbata* var. *'barbata'* (Restionaceae) Gosnells, Western Australia, 16/4/1992, lodged at KINGS PARK, PERTH (acc no. KW 1).

Sori lineares, 1 mm latitudine, 1-50 mm longitudine; peridium ferrugineum; sporae massa nigra, pulverea; sporae ingentia, 6.1- 9.4 µm x (6.8) 8.1- 13.5 µm, levis, saepe cum appendicibus hyalinis; *Lyginiam barbatam* contaminat.

Culms are cylindrical with linear sori, approximately 1mm in width and varying in length from 1mm to greater than 50mm. The sorus is at first covered by a well developed reddish-brown peridium derived from the host epidermis (Fig. 2). This peridium ruptures and flakes away at maturity to reveal the dark blackish-brown, powdery spore-mass. The sori surround the upper internodes often extending from the protective leaf-sheaths and sometimes extending to the base of the next sheath. All smutted culms are sterile (Fig. 1). The teliospores are globose to ellipsoidal, 6.1- 9.4 µm x (6.8) 8.1- 13.5 µm, pale to dark yellow-brown, with smooth walls and often with short, hyaline appendages or thickenings at one or both ends (Fig. 3). All teliospores observed germinated after 24 h on water agar by producing a three-celled promycelium bearing whorls of 2-4 elongated primary basidiospores which gave rise to secondary and tertiary basidiospores (Fig. 4).

On Restionaceae: *Lyginia barbata.* Recorded from 50 km east of Albany to Moore River, north of Perth, Western Australia.



Figs 1 & 2. Culms of *L. barbata* infected by *U. lyginiae*. 1. Heavily infected plant with one or more sori (arrows) on each culm. Note culms have been prevented from flowering. (Bar=4 cm). 2. Close up of a group of sori on the upper portion of a culm (C) showing transverse rupturing (arrows) of the peridium (P). S-scale leaf on culm. (Bar=0.5 cm).

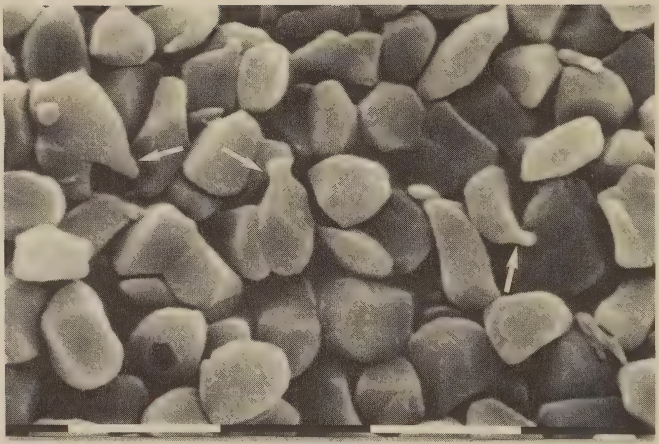


Fig. 3. Teliospores viewed by SEM (Bar=10 μm). Note hyaline appendages (arrows) on some spores.

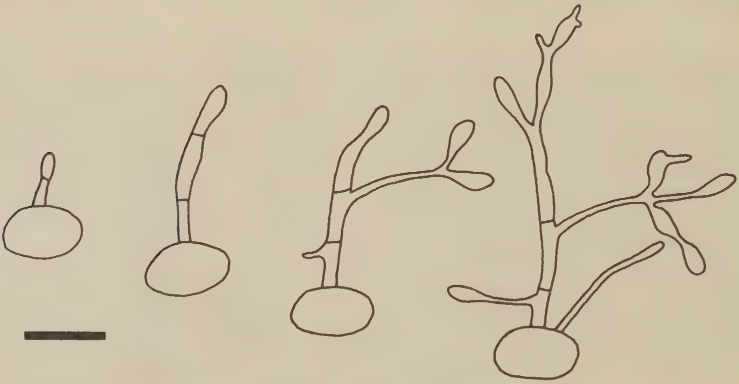
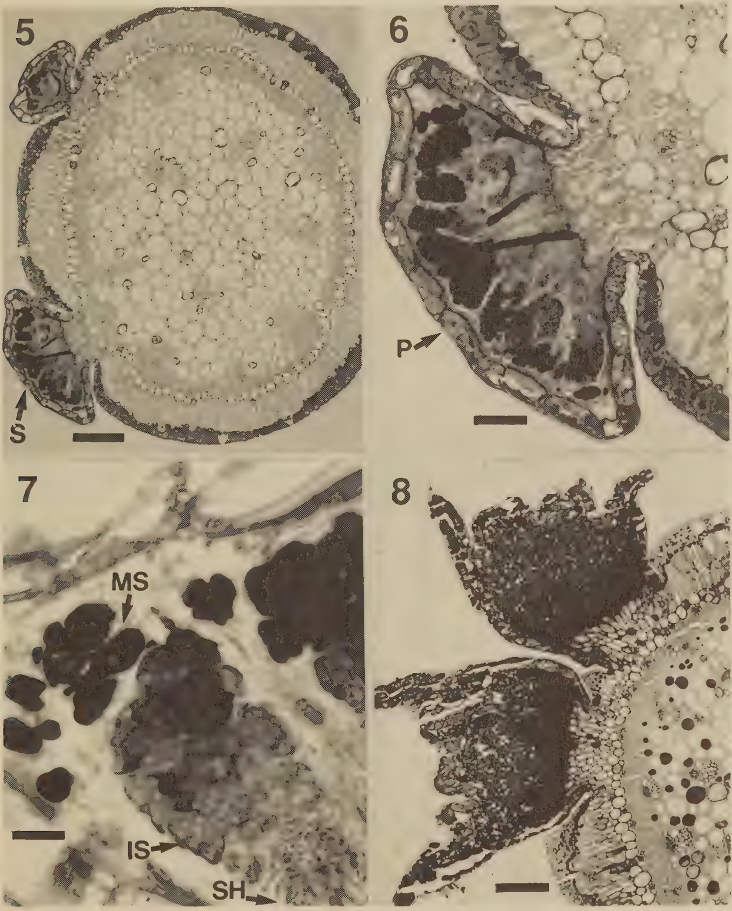


Fig. 4. Camera lucida drawings of different stages of teliospore germination on water agar. (Bar=10 μm).

Transverse sections of an infected culm show that sori develop in depressions on culms and that the soral peridium is composed of host epidermal cells (Fig. 5). The production of tannins in these cells give the peridium a dark red-brown colour compared to the green of healthy epidermal cells on uninfected regions of a culm. A close-up of a young sorus shows teliospores developing in separate lobes emanating from a common mass of sporogenous hyphae at the base of the sorus (Fig. 6). Higher magnification of the young sorus reveals transitional stages of teliospore development radiating outwards through the sorus, from sporogenous hyphae through to compact groups of near mature teliospores (Fig. 7). Compaction in the sorus during teliospore development appears to be responsible for the hyaline appendages present on some teliospores (Fig. 3). At soral maturity all sporogenous hyphae have been transformed into a mass of powdery single teliospores (Fig. 8).



Figs 5-8. Transverse sections of infected culms of *L. barbata*. 5. Transverse section showing two sori (S) developing in depressions on culm. (Bar=176.5 µm). 6. High power view of a young sorus showing peridium (P) composed of host epidermal cells and early stages of teliospore development within the sorus. (Bar=63 µm). 7. Detail of a portion of a sorus showing early spore development. Note sequence of maturation from sporogenous hyphae (SP) to immature spores (IS) and finally mature spores (MS). (Bar=13.8 µm). 8. Transverse section of mature sori immediately prior to spore dehiscence. Virtually all spores are mature at this stage. (Bar=107.3 µm). Sections shown in Figs 5-7 stained with toluidine blue. Section shown in Fig. 8 subjected to PAS staining and counterstaining with toluidine blue.

Table 1: Morphological characters of known culm smuts compared with those of *U. lyginiae.*

Species *	Sori	Peridium	Spore-size µm	wall	polar caps	Host family
U. minima Arthur	culms	+	3.5-4.5(-5) x 4-5(-6)	smooth	not present	Gramineae
U. halophila Speg.	culms	+	5-8	smooth	not present	"
U. hypodytes s.str.	culms	-	3.5-5.5 x 4-6(-7)	smooth-punctate	small to medium sized polar caps in some spores	"
U. williamsii (Griff.) Lavrov	culms & inflor.	-	6-8 x 7-10	smooth	two winged or cup-like, bipolar appendages on all spores	"
U. jacksonii Zundel & Dunlap	culms & inflor.	-	10-14	verruculose	not present	"
U. grandis Fries	culms	+	7-9 x 8-11	smooth-punctate	not present	"
U. lyginiae	culms	+	6.1-9.4 x (6.8) 8.1-13.5	smooth	one or two short appendages or thickenings on some spores	Restionaceae

* According to Vanky (1985, 1990); + present, - absent.

DISCUSSION

The rationale for placing the culm smut of *L. barbata* in the genus *Ustilago*, as are the previously described culm smuts on Gramineae, (Table 1.) is that teliospores are single and teliospore germination is typical for this genus. Table 1 compares the distinguishing features of the known species of culm smut and the new culm smut. The new culm smut is most similar to *U. minima* Arthur and *U. halophila* Speg., having sori on culms only, a peridium and smooth spore walls. However, it differs from these in that its spores are larger (6.1- 9.4 x 8.1- 13.5 µm cf. 3.5-4.5 (5) x 4-5 (6) µm of *U. minima* and 5-8 µm of *U. halophila*) and have small appendages, possibly polar caps, on some spores whereas polar caps are not present in *U. minima* and *U. halophila*. Another important distinguishing feature is that this culm smut has only been found infecting Restionaceae rather than Gramineae. Therefore, it is proposed that the culm smut of *L. barbata* belongs to a new species called *Ustilago lyginiae*, based on sorus and teliospore morphological features and specialization at host family level.

The frequency of disease appears to be related to the level of disturbance, particularly fire. The ecological impact of this and other rush and sedge smuts is currently being examined and will be presented in a forthcoming paper.

ACKNOWLEDGEMENTS

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MYCOTAXON

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Germ plasm in the International Collection of Arbuscular and Vesicular-arbuscular Mycorrhizal Fungi (INVAM) and procedures for culture development, documentation and storage

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Abstract

A living culture collection of endomycorrhizal fungi in Glomales, Zygomycetes was transferred to West Virginia University in 1990, and has since been funded for five years by WVU and the National Science Foundation. Currently, it includes 508 isolates in 46 described and 41 undescribed species of all genera except *Sclerocystis*. Fungal isolates, their origins, and their current status in storage are reported. Hosts, growth media, and containers are standardized to trap indigenous mycorrhizal fungi from native soils and to establish isolate cultures of a species from multiple-spore or single-spore inoculum. All cultures are characterized taxonomically and assigned a unique isolate code based on geographic origin, accession number, and position in a succession of propagation cycles. Vouchers of each isolate include whole and broken spores mounted permanently on slides, whole spores in sodium azide, and color photographs of spore taxonomic features. All germ plasm is stored in dry growth medium at 4°C (cold room) or -196°C (liquid nitrogen). Fungal isolates are available for distribution at cost or through germ plasm exchange. Characterization of fungal germ plasm is supported by taxonomic research to order diversity at the species level and higher and by collaborations with other researchers to document genetic variability, physiological properties, and ecology of organisms at the isolate-level. This information is communicated in a biannual newsletter, exchange of vouchers, and other avenues.

Introduction

Fungi that form endomycorrhizal associations with a broad range of land plants (Glomales, Zygomycetes) are difficult to study because they must be propagated in association with intact plants or root explants. Solid-based media in greenhouse pots has been the method of choice for many years to propagate fungi with plants (Ferguson and Woodhead, 1982). Since cultures require a minimum of 2-3 months to produce high levels of infective propagules, they are susceptible to all the problems attendant with growing plants for such long periods of time and also to contamination by introduced microorganisms. Once cultures are harvested, then problems shift to maintenance of inoculum viablity in storage. Mycorrhizal research programs that are not long-term cannot commit the resources to preservation of germ plasm after experimental goals have been met. As a consequence, many experimental isolates are lost.

A central repository dedicated to acquisition and preservation of living glomalean fungi was first implemented by Dr. Norman Schenck at the University of Florida in 1985 and grew to contain fungal isolates from many international sources. INVAM, as it became known, was transferred in October, 1990 to West Virginia University (WVU) with Dr. Schenck's retirement. The collection included dried inoculum of 270 isolates preserved in liquid nitrogen and 57 in low quantity (50-100 cm^3) that were stored at room temperature. Of the latter, 84% were successfully propagated during 1991. Inocula of the cryopreserved isolates also were transported to Dr. Frank Pfleger at the University of Minnesota, where they are maintained as backup germ plasm. The number of new accessions in the collection has almost doubled since then, with 134 entered in 1992 alone. Until now, most of these isolates have been stored under refrigerated conditions to keep them readily available for internal study or for immediate use by other scientists.

Four objectives of INVAM are continually being carried out: (1) collect and preserve germ plasm of arbuscular and vesicular-arbuscular mycorrhizal fungi originating from varied sources, including individual culture collections, cultotypes of new species, experimental isolates, and fungi endangered by habitat disturbances, (2) propagate a wide range of fungal germplasm in sufficient quantities for distribution to biologists, (3) organize and synthesize information on all comparative studies of accessions, and (4) disseminate all information accumulated in the operation of the culture collection so as to enhance retrieval of novel germplasm and its subsequent use in research. In this paper, we discuss procedures used in the collection to attain these goals and to report an up-to-date listing of germ plasm successfully propagated and stored in the collection.

I. Facilities

INVAM is funded by the Division of Instrumentation and Resources, National Science Foundation and from the Division of Plant and Soil Sciences, College of Agriculture and Forestry, WVU through November, 1995. The staff consists of the curator (Morton), an assistant curator and post-doctoral associate (Bentivenga) and a full-time research assistant (Wheeler). A part-time student is hired during the school term, who generally works 8-10 hours/week.

An advisory committee was selected to help with any problems that might arise in the operation and utilization of the collection. These individuals were chosen for their expertise as well as their proximity to the collection. They include Dr. S. C. Jong, Head of the Mycology Department, American Type Culture Collection; Dr. R. E. Koske, Professor of Botany, Univ. of Rhode Island; Drs. P. D. Millner and S. F. Wright, Research Scientists, USDA-ARS, Beltsville, Maryland; and Dr. David Sylvia, Professor of Soil Science, Univ. of Florida, Gainesville. Most interactions to date have involved collaborations in culture development.

The physical facilities consist of a 1,200 ft^2 laboratory, an adjacent room for processing unsterilized soils, a 225 ft^2 greenhouse with an attached 140 ft^2 headhouse, a 186 ft^2 controlled-temperature growth room, and an 80 ft^2 walk-in cold-storage room. They, along with offices of INVAM staff, are located on the fourth and fifth floors of Brooks Hall on the downtown campus of WVU.

All information collected on each fungal isolate is incorporated into two data bases on three computers stationed in separate rooms. This information includes inventory lists; active cultures; amount of inoculum in storage; and taxonomic, geographic, and ecological data on each isolate. Two computer workstations are set up for desktop publishing to write, publish, and distribute newsletters, brochures, and other communications.

II. Germ Plasm Development

The collection involves many tasks, but those carried out daily or weekly include: (1) establishing cultures of new accessions, (2) separating individual species-isolates from heterogeneous inocula, (3) monitoring propagule viability of single species-isolates stored after air-drying at 4°C, and (4) maintaining homogeneity of cultures through successive propagation cycles. These tasks have been standardized so that they can be carried out efficiently with the staffing resources and the multitude of isolates (50-250) cultured concurrently at any given time. Such standardization occasionally results in the loss of an isolate, but this is balanced by a success rate of over 90% for all accessions introduced into the collection. The general procedure for culture development (Fig. 1) of bulk quantities of a single species-isolate from its native soil environment requires almost one year to complete.

Containers

Cultures are established in either 150 cm^3 cone-tainers, 750 cm^3 Deepots, or 15 cm-diameter (1200 cm^3) plastic pots (Stuewe and Sons, Inc., Corvallis, Oregon). Cone-tainers are always used when seedlings are inoculated with spores to establish single-isolate cultures or when the volume of whole inocula is less than 50 cm^3. Deepots are used when only a small amount of inoculum is to be increased or if space is limiting. Plastic pots are used exclusively for trap cultures and to increase quantities of single-isolate inocula.

Host Plant

Only sudangrass [*Sorghum sudanense* (Staph.) Piper] and sorghum (*Sorghum vulgare* L.) are used for routine propagation of all germ plasm in thecollection. Other hosts, such as asparagus (*Asparagus officinalis* L.) or red clover (*Trifolium pratense* L.), are used, but only for research objectives. Sudangrass is used for "trapping" fungi in native soils or bulk culturing of homogeneous or heterogeneous fungal populations. Sorghum is used for

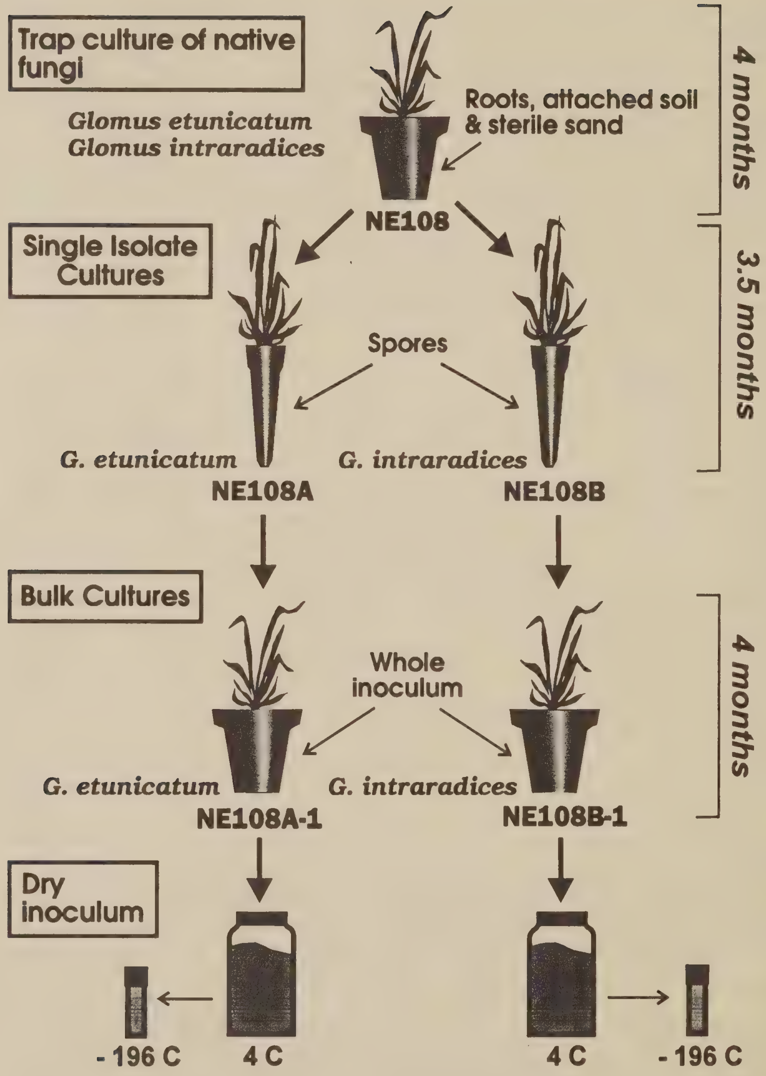
Trap culture of native fungi
Glomus etunicatum
Glomus intraradices
Roots, attached soil & sterile sand
NE108
4 months
Single Isolate Cultures
Spores
G. etunicatum
NE108A
G. intraradices
NE108B
3.5 months
Bulk Cultures
Whole inoculum
G. etunicatum
NE108A-1
G. intraradices
NE108B-1
4 months
Dry inoculum
- 196 C
4 C
4 C
- 196 C

Figure 1. Stages and time-frame for the culture of individual endomycorrhizal fungi in a field soil, from trapping of the mixed population to bulk storage of each isolate as air-dried whole inoculum (growth medium, roots, spores, hyphae).

inoculation of seedlings with spores of fungal isolates. Its root system is hardier and seedlings are much less subject to transplant shock than sudangrass. Currently, success rate of cultures established from sorghum-inoculations is 96% (compared to less than 50% when sudangrass was used).

Sorghum and sudangrass are excellent hosts for a wide range of fungi in West Virginia greenhouse conditions. However, they may not be optimal at all geographic locations. When the culture collection was stationed in Florida, for example, bahia grass (*Paspalum notatum* Flugge) was the most productive host probably because of its tolerance to the high temperature and light conditions prevailing in that climate.

Growth Medium

Despite the different soil environments from which isolates originated, most germ plasm is propagated in a standardized growth medium at pH 6.2. Accessions known to originate from highly alkaline soil environments are grown in the same medium limed with calcium carbonate to an equilibrium pH of 7.5. The soil routinely used is of the Lily series from the edge of a wooded area on the WVU Horticulture Farm near Morgantown. It is a sandy loam Typic Hapludult, sandy loam soil with an average pH of 5.9, 8 mg bicarbonate-extractable P kg^{-1}, and <1% organic matter. The soil is collected from the top 15 cm of the profile, sieved through a wire mesh to a particle size less than 4 mm, and stored slightly moist in closed containers. At the time of use, it is mixed 1:2 (v/v) with #3 Quartzite sand, moistened further, steamed for two 1-hr periods separated by a 24-hr cooling period. It is then incubated for at least 30 days with 2-3 wet-dry cycles to reduce soluble manganese concentrations. Soil pH is monitored during storage to maintain a steady-state environment. This sand-soil mix has proven to be highly versatile, probably because of good cation exchange capacity (reducing the fertilization schedule), aeration, and water retention. It usually is recolonized by microflora (bacteria, saprophytic fungi, and actinomycetes) within 2 weeks, with populations leveling off at average propagule densities of 10^3 CFU/gm soil for each group of organisms.

Other solid substrate media may be used, but they are subject to problems that must be avoided when handling 100-200 different cultures at one time. Millner and Kitt (1992) employ a sand-based medium together with automated watering and fertilization systems. A sand-vermiculite mixture (3:1 v/v) was used in Florida for early INVAM cultures (L. Maia, pers. communication) and fertilized every two days with a 1/10 strength Long Ashton nutrient solution. Root organ cultures are avoided because they have proven to be useful only for isolates of a few species in *Glomus* and *Gigaspora* (Bécard and Piché, 1989). They cannot accommodate the range of germ plasm in the collection. Aeroponic cultures (Hung and Sylvia, 1988) have only limited applicability for a collection like INVAM because of restrictions in the range of fungal species capable of colonization and sporulation.

Trap Cultures

Roots and attached soil of sample plants are collected, chopped so that roots are less than 2-cm lengths, and all components thoroughly mixed. Coarse steamed and moistened sand (#3 Quartzite) then is added in a proportion of 1:1 (v/v) and the mixture placed in 15-cm plastic pots. Between 60-80 seeds of sudangrass are added to the surface in each pot and covered with 1 cm of sterile sand. Cultures are maintained for 4 months. A longer time has proven harmful because of the potential to introduce other mycorrhizal fungi or increase the buildup of other fungal and bacterial propagules detrimental for long-term storage. Fertilization is kept to a minimum, being applied only when plants show signs of phosphorus or nitrogen deficiencies (reddening or yellowing of leaf sheaths, respectively). At harvest, pots are left to dry *in situ* for 1-2 weeks, or until the plants are dessicated. Pot contents are chopped so that root fragments are less than 2 cm long and mixed thoroughly. This is termed "whole inoculum" (Fig. 1) and consists of growth medium, mycorrhizal roots, and fungal propagules (spores, hyphae).

Whole inocula of temperate origin are stored at 4°C for at least one month to overcome suspected dormancy factors in spores. Conversely, inocula of tropical isolates are stored in a room with a constant temperature of 20°C. Longevity of propagules at 4°C is at least one year for almost all isolates, but it differs greatly among isolates for longer periods.

Single-Isolate Cultures

Sorghum is a preferred host compared to sudangrass because it has a hardier root system and the plants are less prone to wilting after transplantation. Surface-sterilized seed (30-40) are added to sterile 15-cm pots containing growth medium (described earlier). Seedlings are removed from the pots for inoculation 10-12 days after emergence. At that time, the contents of a pot are gently massaged to loosen soil and sand from roots and the entire mass placed in a large glass bowl filled with water. Roots are gently teased apart so that individual seedlings can be separated and placed in another clean bowl with water. Seedlings then are grouped in sets of three and roots intertwined by swirling in water.

Extraction of spores of each selected fungus is carried out 1-2 days before inoculation. Spores of similar morphology (color, size, other macroscopic features) are collected under a dissecting microscope with a pasteur pipet having an extruded tip (0.2-0.5 mm opening) and transferred to wells of a microtiter plate, either singly (single-spore inoculum) or in batches of 50-100 (multi-spore inoculum). Care is taken to insure that soil particles, root fragments, or hyphae are not included in the transfer. The spores are stored in distilled water at 4°C until use. When identity of a fungus is in doubt, at least 20 spores also are collected to prepare a slide voucher, with 10 mounted in PVLG[1] and another 10 in PVLG + Melzer's reagent[2] (mixed 1:1 v/v). Broken spores are examined under a compound microscope to verify shared microscopic (subcellular) features.

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[1] 8.33 g polyvinyl alcohol (viscosity of 24-32 centipoise) in 50 ml lactic acid, 50 ml distilled water, and 5 ml glycerin.

Prior to inoculation, clean cone-tainers are sterilized in 10% Chlorox for one hour, rinsed thoroughly, air-dried, and filled with moistened growth medium (described earlier). A hole 1 cm wide and 4-5 cm deep is created in the center of the cone-tainer using a sterile glass rod.

To inoculate, multiple spores in a microtiter well are collected in a pipette and placed along the length of intertwined roots of three seedlings. Excess water in the pipette will drain off roots, but all spores remain attached. When single spores are used, each is placed midway along the root length and nestled carefully amongst intertwined roots. Inoculated seedlings are gently tranplanted into the hole in conetainer, growth medium added to cover roots, and water added.

Inoculated plants are grown for 3 months, at the end of which time a longitudinal section of the soil medium (approximately 25 cm^3) is removed. Spores are extracted and roots stained for mycorrhizae. If both are present, the culture is grown for another 2-4 weeks. Then, watering is terminated so that the contents of each cone-tainer air-dry in preparation for harvest.

Quality Control

Most contamination problems that arise during production of monospecific pot cultures can be traced to three main problems: (1) cultures maintained in the greenhouse for lengthy periods (longer than 4-5 months), (2) excessive or sloppy handling of plants during their growth cycle, (3) water splashing during irrigation of pots, and (4) sharing of facilities by other researchers in which plant and soil materials are neither contained nor sterile. To circumvent these problems, all cultures are propagated in either a greenhouse or a temperature-regulated growth room dedicated to INVAM. Only authorized personnel are allowed to enter the rooms and handle or water plants. Other quality control procedures include:

1. All unsterilized soils are handled and processed in a separate room. All growth media are sterilized before they can be admitted into plant-growth facilities.
2. Floors, bench surfaces, and light fixtures are cleaned with a combined bacteriocide, fungicide, and algicide every few months. An oxidizing biocide mix is added to recycling water in the cooling system during periods of high ventilation in summer months. A "wet-and-dry" vacuum cleaner is used to pick up debris accumulating under benches.
3. Bench surfaces consist of a rigid wire mesh that prevents "puddling" of water around or between pots. All pots or cone-tainers are kept at least 10 and 5

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[2] 1.5 g iodine, 5 g potassium iodide, and 100 g chloral hydrate in 100 ml water.

cm apart, respectively. These surfaces are sterilized when pots are relocated or new pots added. Trap cultures are grown on benches with metal draining trays below the mesh that capture all effluent. The effluent is autoclaved if it is suspected of containing pathogens and then discarded.

4. To prevent cross-contamination among concurrently-growing cultures, at least one cm of sterile growth medium is placed in the bottom and top of each container (regardless of type) at the time of seeding (or transplanting).
5. Insecticides are applied as soon as any aphid, mite, or white fly infestations become apparent.

III. Germ plasm storage

Dried inocula is stored dry at 4°C for short-term duration (6-18 months). Different types of containers are used, depending on quantities produced. Inocula from 15-cm pots are stored in 1-gallon top-locking bags (Associated Bag Co., Milwaukee Wisconsin); those from deepots are placed inside plastic bags and then inserted into 2-quart Mason Jars; and those from cone-tainers are stored in smaller plastic bags with twist-top closures. Five to ten isolates of different species are targeted each year for bulk increase so that they can be mailed out within 72 hours of a request. Usually, 3-4 liters are produced and stored in gallon freezer bags. As can be deduced from the culture list, many other fungi are stored in 0.5-1 liter volumes to respond rapidly to a limited numbers of requests. Regardless of quantity, all inocula stored at 4°C are repropagated within one year after the storage date.

Dried whole inoculum is cryopreserved in liquid nitrogen for long-term storage. Cryopreservation of germ plasm obtained after January, 1991 was delayed until the viability of inoculum stored for longer than one year in liquid nitrogen was tested. In March, 1992, vials of 23 isolates stored for longer than 18 months were thawed and established in cone-tainers (see procedure above). Of these, 82% produced new mycorrhizae and spores. This success rate was very similar to that of the dried inoculum transferred from Florida, suggesting that the disparity in culture conditions is as likely a cause of negative results as viability of inoculum.

The cryopreservation method of Douds and Schenck (1991) is bieng modified to produce more concentrated inocula stored in 1.9 ml vials. After pots contents have dried *in situ*, roots are separated and all remaining growth medium (containing spores and external hyphae) is passed through a sieve with 1 mm openings. This procedure excludes sand particles, which comprise almost 70% of the total medium. The most critical steps in the freezing procedure appear to be: (1) complete drying of the whole inoculum .before freezing and (2) sterilizing sieves between inocula to prevent cross-contamination.

IV. Germ plasm accessions

INVAM always remains open to acquisition of germ plasm minimally passed through at least one propagation cycle in steamed or autoclaved growth medium. At the time of this writing, 506 isolates of 47 described and undescribed species are stored or in the process of being propagated (Table 1). They originate from 19 countries, 32 states (U.S.) and 2 provinces (Canada). Of all genera in Glomales, only the monospecific genus *Sclerocystis* (*S. coremioides* Berk. & Broome) is not represented. In fact, none of the fungi transferred from *Sclerocystis* to *Glomus* are part of the collection, even those isolates reported to have been cultured (Almeida and Schenck, 1990). Information on taxonomy, geography, ecology, and physiology varies greatly among isolates (Table 2). We consider this a normal consequence of the varied history of each isolate and resources of the contributing individuals.

The most widely used approach to promote donation of cultures to INVAM has been a 1:1 exchange of live cultures. Other incentives include: (1) identification of fungal organisms in established cultures in exchange for live inoculum and (2) collaborations to jointly develop cultures of fungi indigenous to new (or old) research sites. Three examples indicate such mutually beneficial exchanges in 1992. Native fungi in sand dunes along a moisture gradient in Namibia, Africa were trapped (NB isolates in Table 2 contributed by K. Jacobson and C. Klopatek) and now are being separated into single species-isolate cultures for further study. Fungi in numerous trap cultures of rhizosphere soils sampled in an old-field pasture site (NC isolates in Table 2 contributed by P. Schultz) were identified and multiple isolates of individual species propagated for molecular analysis of population-level genetic variability. In a Southern-regional Hatch project (S-226) in which inoculant fungi were introduced into fumigated and nonfumigated field plots, trap cultures were established from (a) roots of crop plants at different growth stages, (b) rhizosphere of plants at the end of the experiment, and (c) rhizosphere of plants in uninfested soils (SC isolates in Table 2 contributed by H. Skipper). Both inoculant and native fungi were identified and they are being separated to compare growth promotion properties.

Table 1. Taxonomic distribution of isolates within INVAM.

Genus	Described species	Undescribed species
Acaulospora	11	10
Entrophospora	1	3
Glomus	20	21
Gigaspora	5	0
Scutellospora	10	4

VI. Germ plasm documentation

Each fungal isolate is assigned a unique number. It consists of a three digit accession number preceded by two upper case letters signifying state (in U.S.), province (in Canada) or country of origin, based either on geographic location or address of contributor, depending on the information provided (see Section X). Numbers assigned to isolates in INVAM while at the University of Florida correspond to the accession number. The isolate number also includes an upper case letter after the 3-digit accession number if different species-isolates are partitioned from one culture. For example, NE108A and NE108B are isolates of two different species, *G. etunicatum* and *G. intraradices,* respectively, established in separate cultures from spores of accession NE108. A hyphenated number attached to the code indicates the propagation cycle of the culture. For example, NE108B-2 indicates that *G. intraradices* is in its second subculture after being separated successfully from the mixture in NE108. Voucher specimens are prepared at the time any culture is harvested. Three kinds of specimens are preserved within the collection.

Slides. A small quantity of polyvinyl alcohol-lactic acid-glycerin (PVLG) and PVLG + Melzer's reagent (mixed 1:1 v/v) are each placed on a clean glass slide. Between 10-40 spores are placed in each mountant, which then is left to harden slightly (10-15 minutes). A coverslip is placed over each drop and pressure applied to break individual spores. Over 2000 slides are stored in the INVAM library, grouped by species in flat metal trays filed in oak boxes.

Vials. Intact spores numbering between 50-1000 are collected with all associated root, soil, and hyphal debris removed and then placed in 2.0 ml glass vials containing 0.05% sodium azide or 0.5% formalin. Each vial is given a unique voucher number and cross-referenced to other voucher specimens and the live culture. Over 900 vials currently are cataloged and stored at 4^{O}C.

Color photographs. Fresh whole spores are photographed through a Bauch and Lomb stereomicroscope, and all subcellular structures of broken spores are recorded through a Nikon Optiphot Research Microscope with brightfield or differential contrast optics. Images are captured with a Sony Model DXC-107 color video camera, framed on a Sony 14-inch high resolution monitor, and then printed on 4 × 5.5-inch paper from a Sony Model UP-3000 Color Video Printer (B & B Microscopes, Pittsburgh, Pennsylvania). The printer is programmed to accept one image (whole spores) or four images per print (various views of broken spores in PVLG and PVLG + Melzer's reagent). Black and white images are scanned into computer files using a Logitech 256 hand-scanner and Ansel editing software. Each photograph is assigned a unique number and cross-referenced to all other voucher specimens. The photo collection currently exceeds 1000 images of intact and broken spores.

All information on INVAM accessions is entered into Omnis 7, a programmable database distributed by Blythe Software, Inc. (1065 E. Hillsdale Blvd., Foster City, California). The culture data base includes data on all new accessions and subcultures, as well as amount and location of stored inoculum. The voucher database keeps track of method of specimen preservation, storage location, and cross-references to culture isolates. A separate taxonomic database is being developed as characters are redefined and developmental information collected on each isolate. From this information, we expect to combine dichotomous and synoptic keys with scanned graphic images.

V. Germ plasm distribution

Germ plasm development involves one year of work and at least three propagation cycles (Fig. 1). The cost of this process is estimated at more than $400 for each isolate, excluding storage and maintenance costs. We charge a nominal fee of $25 for 175 cm^3 of "whole" inoculum, with all other costs subsidized by NSF and WVU. A large number of isolates are maintained in large enough quantities (Table 2) to mail out within 72 hours after receiving a request, as long as the demand is not too great. Of the 156 isolates distributed in 1992, all but 4 were mailed out within 7 days. This will change as more isolates are cryopreserved. For those, thawing and subsequent propagation to increase inoculum bulk will entail a delay of 90-100 days. The funds collected from distributed cultures are reinvested in service functions that promote characterization of germ plasm (see Section VII). Some of these funds also subsidize cultures for students or other individuals who have no financial support to carry out research activities.

VI. Research Activities

Research efforts are oriented toward optimizing characterization of fungal isolates and in gathering information to minimize changes in properties of these fungi as a result of propagation. All of these efforts are essential to maintain order in the collection, to track individual isolates, and to help users of the collection to make intelligent germ plasm choices.

Systematic studies

Many of the fungi in the collection remain taxonomically unresolved (Table 1). Given the state of glomalean taxonomy (Morton, 1993), even names of described species assigned to isolates are equivocal. Developmental studies are being conducted on many isolates as a natural extension of standard operations to monitor cultures at all stages of their propagation cycles. Already, this work is leading to a complete revision of character concepts and their value in alpha taxonomy (nomenclature, diagnosis) and systematics (study of evolutionary relationships). Results will provide a more robust measure of biogeographic distribution of species and a more definitive reference to study diversity at other levels of organization (Morton and Bentivenga, 1993).

Molecular studies

Molecular studies provide the only means to define "individual" or "population" level variation because morphological characters have no resolving power below the species level (Morton and Bentivenga, 1993). We have begun to implement a two-tiered approach in collaborations with other researchers. The first step is to obtain a wide range of fungal isolates of a species from within a given geographic range. These isolates can be compared to assess intraspecific variation by the criterion of choice, such as patterns of random amplified polymorphic DNA (RAPD), restriction fragment-length polymorphic DNA (RFLP), fatty acid-methyl ester (FAME) or isoenzyme comparisons. The second step is the bring the resources of the collection to bear in culture isolates of the same species from more distant geographic regions for broader comparisons.

Ecological studies

The ecological conditions at the site from which an isolate was extracted are important determinants in culture development. These must be defined to determine culture and storage conditions. Data on accessions most commonly includes host association, soil pH and soil phosphorus levels (Table 2). We consider soil properties (pH, texture, temperature, moisture) to be most important in evaluating conditions for culturing a new accession. Unfortunately, most ecological information often is obtained *after* propagation has begun. Information on some isolates in the collection is known, but has not yet been communicated to INVAM (see Table 2).

There is little evidence that glomalean fungi reproduce sexually. Not only is each isolate likely to be genetically isolated from all others, but genetic changes that may arise during a propagation cycle could be rapidly fixed in all new propagules with directed selection. Currently, we have no knowledge of the rates at which genetic changes occur or what kinds of selection pressures alter the mycorrhizal phenotype. In the absence of genetic or biochemical markers to monitor these changes, the conservative solution is to conserve the genotype of the parent accession through cryopreservation. This practice has not yet been implemented.

In early stages of culture development (Fig. 1), fungi from two or more species often are present together. Competition effects in the pot environment can significantly affect interpretations of culture composition. Some fungi appear to vanish because spores no longer are detectable. However, we are finding that these fungi can still maintain a low level colonization and appear in later cycles of propagation (if started from whole inoculum). Most "contaminant" glomalean fungi appear to originate from within a culture rather than through introduction from an external source. Therefore, different procedures are being developed to retrieve fungi in low numerical abundance.

Physiological studies

Only a limited number of isolates in the collection have been shown experimentally to promote growth relative to nonmycorrhizal plants (Table 2). Very little is actually known about the magnitude of variation within a species or the causal processes involved. More isolates need to be characterized, but this experimental work can be carried out only on a limited scale within the INVAM project. A benefit of distributing isolates to investigators is that the data they collect can be incorporated into the germ plasm database. An important responsibility is to track this information as it becomes available.

VII. Service Activities

The main service function of INVAM is to provide information on cultures in the collection as they are made available for distribution. A newsletter has been published twice each year since September, 1990. Until now, all articles have been written by Morton, with some input from other scientists. More contributions are needed by others working with cultures if the scope of the newsletter is to increase. Currently, all typing, desktop formatting and editing, copying, and mailing chores are carried out internally by INVAM staff to keep costs down. New equipment now permits incorporation of 2400 dpi resolution photographs into the newsletter, facilitating communication of new taxonomic information obtained on culture isolates.

Morton (1988) deemphasized color as an important morphological character in defining species of glomalean fungi. While this conclusion is true for field-collected or preserved spores easily modified by environmental factors, it is incorrect for spores *collected fresh from pot cultures.* Variation in color is much narrower in some fungal groups than in others, and appears to be a function of developmental constraints (manuscripts in preparation). An INVAM color chart has been generated from the computer software program CorelDraw (Corel Corporation, 1600 Carling Ave., Ottawa, Canada) to better analyze color as a taxonomic character. This color chart was printed using funds from culture sales. It is available to interested persons at no cost.

Slide and photographic vouchers of all isolates in the collection are available on a loan basis, after specific arrangements are made to insure their safe return. Experimental isolates can be identified by INVAM at no cost, as long as a portion of the culture is submitted as an accession (see Section V).

X. Germ plasm catalog

All living fungal isolates housed in the collection are listed in Table 2. The two letter code preceding each 3-digit accession number translates as follows:

United States. AZ = Arizona, CA = California, FL = Florida, GA = Georgia, HA = Hawaii, IA = Iowa, IL = Illinois, IN = Indiana, KS = Kansas, KY = Kentucky, MA = Massachusetts, MD = Maryland, MI = Michigan, MN = Minnesota, MS = Mississippi, MT = Montana, NC = North Carolina, NE = Nebraska, NJ = New Jersey, NM = New Mexico, NV = Nevada, NY = New York, OR = Oregon, PA = Pennsylvania, RI = Rhode Island, SC = South Carolina, TX = Texas, UT = Utah, VA = Virgina, WA = Washington, WI = Wisconsin, WV = West Virginia.
Canadian provinces. SA = Saskatchewan, ON = Ontario.
Other countries. AU = Australia, BR = Brazil, CL = Colombia, DN = Denmark, FR = France, GR = Germany, ML = Malaysia, MX = Mexico, NB = Namibia, NG = Niger, PL = Poland, SN = Singapore, SW = Switzerland, SY = Syria, TL = Thailand, UK = United Kingdom, VZ = Venezuela.

Fungal genera are abbreviated as follows: A.= *Acaulospora*; E.= *Entrophospora*; G.= *Glomus*; Gi.= *Gigaspora*; S.= *Scutellospora*

Cryopreserved isolates were identified by N. C. Schenck; all others were assigned species names at WVU. Equivocal identifications of described species are indicated with a question mark. Fungi with only a genus name are either undescribed or they cannot be assigned to a species with available information. Species provisionally synonymized in this list include: *A. gerdemannii* Schenck & Nicol. = *A. appendicula* Spain, Sieverding & Schenck, *A. dilatata* Morton = *A. morrowiae* Spain & Schenck, *A. delicata* Walker, Pfeiffer & Bloss = *A. longula* Spain & Schenck, *A. bireticulata* Rothwell & Trappe = *A. elegans* Trappe & Gerd., *G. clarum* Nicol. & Schenck = *G. manihotis* Howeler, Sieverding & Schenck, *G. mosseae* (Nicol. & Gerd.) Gerd. & Trappe = *G. monosporum* Gerd. & Trappe, *G. aggregatum* Schenk & Smith = *G. intraradices* Schenk & Smith, and *S. heterogama* (Nicol. & Gerd.) Walker & Sanders = *S. dipapillosa* (Walker & Koske) Walker & Sanders. Origin of an isolate is identified either by address of the contributor (asterisk) when no other information is specified, or by the geographic location. Volume of dry inoculum stored at 4°C is reported in three categories: Dry^1 = < 500 cm^3, Dry^2 = between 500-1000 cm^3, and Dry^3 = > 1000 cm^3. Fungal isolates on which information exists (personal communication or published) of plant growth-promotion effects are highlighted in bold face.

Table 2. List of germ plasm currently being propagated (P) or stored as dry inoculum at 4°C (Dry) or -196°C (N_2). Other details are explained in text above.

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
FL130-3	*A. appendicula/ G. leptotichum*	Dudeck/ Gainesville	Leon sandy siliceous, thermic; turf experiment	Dry^1
CL139	*A. denticulata*	Sieverding/ Timbío, Cauca	CIAT C-139-1; Pot culture soil with *Pueraria phasioloides*, pH 5.1, 2.3 ppm P, 13.5% o.m.	Dry^1
CA886	*A. elegans*	Oruko/ UC Davis	Information not provided	N_2
WV110	*A. lacunosa*	Morton/ Manown	*Danthonia spicatum*; pH 4.2, < 2 ppm P, 62% Al saturation	Dry^2
WV615-1	*A. lacunosa*	Morton/ Bald Knob	*Festuca arundinacea*; limed refuse, seeded with plant mix; pH 5.7	Dry^1
WV613-1	*A. lacunosa/ Glomus* sp.	Morton/ Bald Knob	*Trifolium repens*; limed coal refuse and seeded with plant mix; pH 5.7	Dry^3
WV685-1	*A. laevigatum* nom. ined.	Morton/ Manown	*Andropogon virginicus*; acid mine drainage; pH 3.7, 81% Al saturation	Dry^1
WV736	*A. laevigatum* nom. ined.	Dant/ Brandonville	*Lotus corniculatus*; pH 4.4, 6 ppm P, 1.8 meq Al, 2% o.m.	Dry^3
WV913A-1	*A. laevigatum* nom. ined.	Morton/ Manown	*Andropogon virginicus*; black gob pile, pH 4.3	Dry^1

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
WV102-1	*A. laevigatum* nom. ined.	Morton/ Cassville	*Festuca arundinacea*; pH 5.7, 23 ppm P,136 ppm K	Dry[1]
WV103-1	*A. laevigatum* nom. ined.	Morton/ Cassville	*Andropogon virginicus* & *Rosa multiflora*; pH 4.5, 15 ppm P, 218 ppm K	Dry[2]
AU211	*A. laevis*	Gazey/ Mt. Barker	WUM 11(1); farmed as a wheat paddock 24 yrs	Dry[1]
AU221	*A. laevis*	Gazey/ Badgingarra	WUM 11(4); from pasture soil	Dry[1]
AZ661-1	*A. longula*	Pfeiffer/ Tuscon	Ornamentals in greenhouse	Dry[2]
CL282	*A. longula*	Spain/Meta, Carimagua	CIAT C-12-1; savanna grasses; pH 4, 2 ppm P, 83% Al, 3.2% o.m.	N_2
CL373	*A. longula*	Howeler/ Magdalena	CIAT C-17-2; *Manihot esculenta*; pH 4.8	N_2
CL853-1	*A. longula*	Sieverding/ Chocó	CIAT C-42-7; *Meta* sp.	Dry[1]
FL575-1	*A. longula*	Not specified	No information	Dry[1]
GR992	*A. longula?*	Moawad/ Gottingen	No information	N_2
BR152A-1	*A. mellea*	Ming Lin/ Campinas*	No information	Dry[2]
CL538	*A. mellea*	Sieverding/Cauca, Popayán	CIAT C-3-17; *Manihot esculenta*	N_2
CL551-1	*A. mellea*	Sieverding/Cauca, Mondomo	CIAT C-19-7; *Manihot esculenta*	Dry[3]
CL702	*A. mellea*	Toro/Puerto Tejada	CIAT C-121-1A; *Saccharum* sp.	N_2
FL219B-2	*A. mellea*	Schenck/ Gainesville*	No information	P
FL244-4	*A. mellea*	Johnson/ Dade County	*Simarouba glauca*, Castello hammock	Dry[2]
FL266-2	*A. mellea*	Johnson/ Tallahassee	Maclay Gardens	Dry[2]
FL312A-1	*A. mellea*	Sylvia/ Gainesville	Contaminant in S312 subculture at WVU	Dry[2]
FL479	*A. mellea*	Schenck/ Gainesville	Contaminant in sterile control pot	N_2
MN350	*A. mellea*	Miller/ Shakopee	*Malus domestica*; first in *Secale*; Lesauk clay loam, pH 5.9, 41 ppm P	N_2
FL926	*A. mellea?*	Pérez/ Gainesville	*Allium* sp.; park in town	N_2
NC113-1	*A. mellea?*	Schultz/ Durham	Old field; site B-21-33	Dry[1]
NC114C-1	*A. mellea?*	Schultz/ Durham	Old field; site D-24-33	Dry[1]

INVAM Isolate	**Fungal Species**	**Source Person/ Origin**	**Host-Soil-Environment**	**Store**
NC115C-1	*A. mellea*?	Schultz/Durham	Old field; site D-10-39	Dry[1]
NC116	*A. mellea*?	Schultz/Durham	Old field; site A-18-6	Dry[1]
NC119A-1	*A. mellea*?	Schultz/Durham	Old field; site D-8-54	P
BR801	*A. morrowiae*	Spain/Bahia, Itabuna	Legumes in pasture	N_2
BR983-1	*A. morrowiae*	Maia/ Pernambuco	*Zea mays*; Latosol; pH 6.3, low P	Dry[1]
CL358-2	*A. morrowiae*	Spain/Meta, Carimagua	CIAT C-14; native savanna grasses, pH 5.5	Dry[2]
CL508	*A. morrowiae*	Sieverding/Cauca, Quilichao	CIAT C-37-9; *Stylosanthes* sp.	N_2
CL525-2	*A. morrowiae*	de Castellano/ Bogotá	CIAT C-132-2A; *Ficus carica*; from ornamental nursery	Dry[1]
CL649-1	*A. morrowiae*	de Castellano/ Bogotá	CIAT C-134-11; near greenhouse; weeds	Dry[1]
CL652	*A. morrowiae*	Sieverding/Cauca, Popayán	CIAT C-3-6; *Manihot esculenta*	N_2
FL415-2	*A. morrowiae*	Johnson/ Tallahassee	*Myrica cerifera*; Maclay Gardens in oak forest	Dry[1]
WV107-1	*A. morrowiae*	Morton/ Coopers Rocks	*Andropogon virginicus*; pH 3.7, 17 ppm P, 76% Al saturation	Dry[1]
CL316	*A. morrowiae*?	Spain/Meta, Carimagua	CIAT MC-12-1; savanna grasses; very acid	N_2
CL539	*A. morrowiae*?	Sieverding/Cauca, Mondomito	CIAT C-4-9; *Manihot esculenta*	N_2
CL828	*A. morrowiae*?	de Castellano/ Bogotá	CIAT C-130-7; *Pennisetum clandestinum*	N_2
CL372-2	*A. rugosa*	Spain/Meta, Carimagua	CIAT C-12; native savanna grasses	Dry[1]
FL391	*A. rugosa*	Schenck/ Gainesville*	No information	N_2
FL443-2	*A. rugosa*	Pérez/ Crescent Beach	*Canavalia rosea*; weedy lot	Dry[2]
FL857-1	*A. rugosa*	Schenck/ Gainesville	Contaminant in FL356 culture	Dry[1]
FL981-2	*A. rugosa*	O'Keefe/ Gainesville*	*Desmodium* sp; acid soil	Dry[1]
GA297	*A. rugosa*	Smith/ Athens	*Gossypium hirsutum;* Expt. Stn. microplots	N_2
GA394	*A. rugosa*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	N_2
WV664-2	*A. rugosa*	Morton/ Lenox	*Trifolium repens*; pH 4.2, 2.3 ppm P, 33% Al	Dry[2]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
WV949-2	*A. rugosa*	Dant/ Osage	*Andropogon virginicus*; abandoned minesite, pH 4.2, < 2 ppm P	Dry^3
WV952-1	*A. rugosa/* *Gi. gigantea*	Morton/ Morgantown	*Danthonia spicata*; abandoned pasture, south slope, pH 4.5	Dry^1
BR456-1	*A. scrobiculata*	Schenck/ Minas Gerais	*Manihot esculenta*	Dry^2
BR984A-3	*A. scrobiculata*	Maia/ Pernambuco	*Manihot esculenta*; pH 5.6; low P	P
FL995-2	*A. scrobiculata*	Pérez/Canal Point Station	*Saccharum officinarum*; muck sample	Dry^1
VA104-2	*A. scrobiculata*	Walker/ Assateague	*Solidago* and *Ammophila* mixture; sand dune	P
WI994A-2	*A. scrobiculata*	Miller/ Sturgeon Bay	*Malus domestica*; first in fallow; Longrie silt loam, pH 6.6, 65 ppm P	Dry^1
BR984-2	*A. scrobiculata/* *A. mellea*	Maia/ Pernambuco	*Manihot esculenta*; pH 5.6; low P	Dry^2
BR207	*A. scrobiculata?*	Sturmer/ Azambuja	*Vitis labrusca*; pH 8.2, 13 ppm P, 3.6% o.m.	Dry^1
FL257-3	*A. spinosa*	Johnson/ Tallahassee	*Myrica cerifera*; oak-dominated forest	Dry^1
GA326	*A. spinosa*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	N_2
WV861A-2	*A. spinosa*	Morton/ Kearnysville	*Zea mays;* sandy loam, pH 6.4, 39 ppm P	Dry^1
MX982-1	*A. spinosa/* *G. leptotichum*	Pardo/Mexico City	No information	Dry^1
NC105-2	*A. spinosa/* *G. claroideum*	Schultz/ Durham	8-yr-old pasture; pH 6.7	Dry^2
AU219	*A. trappei*	Gazey/Perth	WUM 19(1); contaminant in sub clover pot culture	Dry^1
NB128	*A. trappei*	Klopatek/ Eastern Plain	*Zygophyllum staphii* (shrub)	Dry^1
NC104B-3	*A. trappei*	Hoefnagels/ Dills Creek	*Spartina patens*; wetland	Dry^1
SC203	*A. trappei*	Skipper/ Clemson	MB-fumigated wheat field; native fungi in soybean host	P
NB112-1	*A. trappei/* *Glomus* sp.	Klopatek/Semi-desert-savanna transition zone	*Myrothamnus flabelliofolia* (shrub)	Dry^2
SC504	*A. trappei/* *Glomus* sp.	Skipper/ Clemson	MB-fumigated wheat field; native fungi in soybean host	Dry^1
AU215	*Acaulospora* sp./ *G. occultum*	Brundrett/ Kakadu Nat'l Park, N.T.	ARR site 17; open *Eucalyptus* wood-land, pH 5.7, 5 ppm P	Dry^1

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
BR210	*Acaulospora* sp.	Sturmer/ Cacador	*Pyrus caleriana*; pH 5.2, 30 ppm P, 4.4% o.m.	Dry[2]
BR874-1	*Acaulospora* sp.	Sturmer/ Joaquina	*Ammophila*; sand dune	Dry[1]
BR875-1	*Acaulospora* sp.	Trufem/ Sao Paulo	Dune grasses. No other information	Dry[2]
CL536	*Acaulospora* sp.	Castilla/ Puerto Asís	CIAT C-24-4; *Andropogon gayanus*	N_2
CL735-2	*Acaulospora* sp.	Sieverding/Cauca, Mondomo	CIAT C-123-7; *Manihot esculenta*	Dry[1]
CL971-2	*Acaulospora* sp.	Not specified	CIAT isolate, no other information	Dry[2]
FL656	*Acaulospora* sp.	Schenck/ Gainesville*	No information	Dry[3]
HA726A-1	*Acaulospora* sp. (70-80 µm)	Koske/Puhimau	*Andropogon virginicus*; non-thermal soil	Dry[1]
HA726B-1	*Acaulospora* sp. (90-100 µm)	Koske/Puhimau	*Andropogon virginicus*; non-thermal soil	Dry[1]
NB131	*Acaulospora* sp.	Klopatek/ Gobabeb	*Aloe asperifolia* (shrub), eastern plains	Dry[1]
NC120B-1	*Acaulospora* sp.	Schultz/ Durham	Old field; site B-15-39	Dry[1]
UK123	*Acaulospora* sp.	Morton/ Glen Coe	Grass near stream amongst *Calluna*; flat	Dry[1]
UK124	*Acaulospora* sp.	Walker/ St. Helens	From pot culture with *Plantago*	Dry[2]
VZ101	*Acaulospora* sp.	Leal/ El Tigre	pH 4.7, 9.3 ppm P, 22% Al saturation, < 1% o.m.	Dry[2]
VZ104	*Acaulospora* sp.	Leal/ El Tigre	pH 4.9, 8 ppm P, 18% Al saturation, < 1% o.m.	Dry[2]
AU103-2	*Acaulospora* sp./ *G. etunicatum*	Gazey/Lancelin	WUM 18(1); *Banksia* bushland; pH 5.5, 1-2 ppm P, 0.8% o.m.	Dry[1]
BR217	*Acaulospora* sp./ *Gi. albida*	Sturmer/Santa Catarina State	*Vitis labrusca*; pH 5.3, 25 ppm P, 6.8% o.m.	Dry[1]
NG107A	*Acaulospora sp./ A. appendicula*	Vetterlein/ Sadoré	*Agropyron repens*; trap culture; pH 4.3	Dry[2]
BR145-1	*E. colombiana*	Ming Lin/ Campinas*	No information	Dry[1]
BR148A-2	*E. colombiana*	Ming Lin/ Campinas*	No information	Dry[1]
FL356-5	*E. colombiana*	Schenck/ Gainesville*	No information	Dry[2]
GA101-1	*E. colombiana*	Wilson/ Athens	*Sorghum vulgare;* low growth promotion	Dry[1]
BR148-1	*E. colombiana/ G. clarum*	Ming Lin/ Campinas*	No information	Dry[3]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
VA105E-2	*E. contigua*	Walker/ Assateague	Mix of *Ammophila* & *Solidago*; fine sand, pH 6.2-6.8, <10 ppm P	P
VA105-1	*E. contigua* nom. nom./*G. clarum*	Walker/ Assateague	*Ammophila breviguIata*; sand dune	Dry[1]
WV109B-1	*E. contigua* nom. ined.	Morton/ Manown	*Andropogon virginicus*; pH 4.1, < 2 ppm P, 62% Al saturation	P
WV201-2	*E. contigua* nom. ined.	Morton/ Coopers Rocks	*Andropogon virginicus*; stripmine, pH 3.7, 17 ppm P, 76% Al saturation	P
BR947	*Entrophospora* sp.	Schenck/ Sao Paulo	Grape; greenhouse pot culture	N_2
CL283-1	*Entrophospora* sp.	Spain/Meta, Carimagua	CIAT C-11-1; savanna grasses; pH 4, 2 ppm P, 83% Al, 3.2% o.m.	Dry[1]
FL137-2	*Entrophospora* sp.	Dudeck/ Gainesville	Leon sandy siliceous, thermic; turf experiment	Dry[1]
FL997	*Entrophospora* sp.	Schenck/ Goulds	In Castello Hammock	N_2
NC103A-2	*Entrophospora* sp.	Hoefnagels/ Beaufort	*Spartina patens*; wetland	Dry[1]
NC104A-3	*Entrophospora* sp.	Hoefnagels/ Dills Creek	*Spartina patens*; wetland	Dry[1]
MN351	*G. aggregatum*?	Pfleger/ Lamberton	Agricultural soil; pH 7.4, 15 ppm P.	P
FL989	*G. ambisporum*?	Sylvia/ Gainesville*	S328 entry. No other information	N_2
FL295	*G. caledonium*	Schenck/ Gainesville	No information	N_2
GA313-2	*G. caledonium*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	Dry[2]
IA330	*G. caledonium*	Miller/ Ames	*Malus domestica*; first in sudangrass; Clarion silt loam, pH 6.4, 13 ppm P	N_2
UK361	*G. caledonium* or *G. mosseae*	Schenck/ Rothamsted	E2 isolate; Ashridge soil	N_2
DN986	*G. caledonium*?	Jakobsen/ Roskilde	Isolate RIS42.	P
OR209-2	*G. caledonium*?	Hetrick/ Corvallis*	*Allium* sp.	Dry[2]
UK301	*G. caledonium*?	Cargeeg/ Rothamsted	E3 isolate. No other information	P
WI409-2	*G. caledonium*?	Miller/ Sturgeon Bay	*Malus domestica*; first in fallow; Longrie silt loam, pH 6.6, 65 ppm P	Dry[2]
CA458	*G. claroideum*	Oruko/ UC Davis	No information	N_2
FL976	*G. claroideum*	Schenck/ Bartow	*Atriplex* sp.; Bonnie Lake phosphate mine, pH 5.5	N_2

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
KY306	*G. claroideum*	Hendrix/ Lexington	No information at this time	N_2
ML918	*G. claroideum*	Unspecified	No information	N_2
MN353	*G. claroideum*	Pfleger/ Lamberton	*Trifolium repens*, taconite tailings; pH 8.7, 1 ppm P, 100 ppm Fe, 3% o.m.	P
SC186-1	*G. claroideum*	Skipper/ Clemson	*Glycine max*; pot culture contaminant; moderate growth promotion	Dry[1]
CL698-2	*G. claroideum/ G. intraradices*	Sieverding/Cauca; Quilichao	CIAT C-1-3; *Manihot esculenta*; pH 4, 2.7 ppm P, 4.8 meq Al, 6% o.m.	Dry[2]
PA108	*G. claroideum/ G. diaphanum?*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry[1]
SC201	*G. claroideum/ G. etunicatum?*	Skipper/ Clemson	Soybean in V4 stage from wheat field; *G. claroideum* added	P
BR151B-2	*G. claroideum?*	Ming Lin/ Campinas*	No information	P
FL669	*G. claroideum?*	Schenck/ Gainesville*	No information	N_2
FL728B-2	*G. claroideum?*	Sylvia/ Bartow	Contaminant in S332	Dry[1]
FL925	*G. claroideum?*	Sylvia/ Anastasia Isle	S328 entry; *Uniola paniculata;* pioneer dune	N_2
MT680	*G. claroideum?*	Grey/ Holland	*Hordeum vulgare*	Dry[1]
UT171-3	*G. claroideum?*	Wood/Salt Lake City*	Proprietary to Native Plants, Inc.	Dry[3]
BR147-2	*G. claroideum?.*	Ming Lin/ Campinas*	No information	Dry[1]
BR143A-2	*G. clarum*	Ming Lin/ Campinas*	No information	Dry[2]
BR144-2	*G. clarum*	Ming Lin/ Campinas*	No information	Dry[2]
BR152B-1	*G. clarum*	Ming Lin/ Campinas*	No information	P
BR213	*G. clarum*	Sturmer/ Tres Barras	*Eucalyptus dunnii*; 900 m altitude	Dry[1]
CL281	*G. clarum*	Spain/Cauca, Quilichao	CIAT isolate; *Manihot esculenta*	N_2
CL696	*G. clarum*	Sieverding/ Valle, Palmira	CIAT C-150; *Pueraria phaseoloides*	N_2
CL976-2	*G. clarum*	Sieverding/ Cauca	CIAT C-151. *Manihot esculenta*	Dry[1]
FL204	*G. clarum*	Unknown	No information	N_2
FL239-3	*G. clarum*	Schenck/ Gainesville	Contaminant in culture of *G. leptotichum*	Dry[1]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
FL879-2	*G. clarum*	Sylvia/ White Springs	S337; *Prunus*; Occidental phosphate mine	Dry[2]
GA980	*G. clarum*	Bartolome/ Griffin	Grassland; sandy clay loam, pH 4.3, 7 ppm P, 78 ppm Al, 1.1% o.m.	N_2
KY305	*G. clarum*	Hendrix/ Lexington	*Nicotiana*; limed soil	N_2
NB119	*G. clarum*	Klopatek/Semi-desert-savanna transition zone	*Pennisetum foermeranum* (grass)	Dry[1]
NC112	*G. clarum*	Schultz/ Durham	Old field; site C-42-1	Dry[2]
VA105D-2	*G. clarum*	Walker/ Assateague	Mix of *Ammophila* & *Solidago*; fine sand, pH 6.2-6.8, <10 ppm P	Dry[1]
WV101-1	*G. clarum*	Morton/ Cassville	*Festuca arundinacea* with *Rosa multiflora*; pH 4.5, 15 ppm P, 218 ppm K	Dry[1]
WV751-3	*G. clarum*	Morton/ Morgantown	Native pasture near maple forest	Dry[2]
WV848A-1	*G. clarum*	Morton/ Bald Knob	*Danthonia spicata*; abandoned minesoil, pH 4.2, < 2 ppm P	Dry[1]
WV858A-1	*G. clarum*	Morton/ Manown	*Andropogon virginicus*; near acid mine drainage, pH 3.8, 72% Al sat.	Dry[1]
WV979A-1	*G. clarum*	Morton/ Sabraton	*Robinia pseudoacacia*; pH 4.5, 4.7 ppm P, 39% Al saturation	Dry[1]
CL883-1	*G. clarum/ G. intraradices*	Shirey/ Bogotá	Legume pasture	Dry[1]
FL979-1	*G. clarum/ G. etunicatum*	Morton/ Gainesville	Grasses recolonizing sink hole	Dry[1]
HA725-1	*G. clarum/ Acaulospora* sp.	Koske/Puhimau	*Andropogon virginicus*; non-thermal soil	Dry[1]
SY711-1	*G. clarum/ G. etunicatum*	Sands/Allepo	*Hordeum vulgare* nursery	Dry[1]
CA113	*G. deserticola*	Watson/ Beltsville*	Isolate from Menge's GH, cultured on corn, pH 7.6	P
NV104	*G. deserticola*	Allen/Reno	*Artemesia tridentata* transplanted to GH	P
SN912	*G. deserticola*	Louis/ Natl. Univ.	*Rhynchelytrum repens*; reclaimed marine sand	N_2
WV579B-2	*G. diaphanum*	Morton/ Pumpkintown	*Trifolium pratense*; reclaimed coal mine, pH 4.6, 4 ppm P, 2% o.m.	Dry[1]
GR582-2	*G. diaphanum?*	Dehne/ Hannover	No information	Dry[1]

INVAM Isolate	**Fungal Species**	**Source Person/ Origin**	**Host-Soil-Environment**	**Store**
UT183-1	*G. etunicatum*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^2
BR106	*G. etunicatum*	Spain/Brazilia*	No information at this time	Dry^1
BR109	*G. etunicatum*	Spain/Brazilia*	No information at this time	Dry^1
BR149-4	*G. etunicatum*	Ming Lin/ Campinas*	No information at this time	Dry^1
BR151C-2	*G. etunicatum*	Ming Lin/ Campinas*	No information at this time	Dry^1
BR215	*G. etunicatum*	Sturmer/Santa Catarina State	*Vitis labrusca*; pH 6.2, 13 ppm P, 3.6% o.m.	Dry^1
BR216	*G. etunicatum*	Sturmer/Santa Catarina State	*Vitis labrusca*	Dry^1
BR220	*G. etunicatum*	Sturmer/Sao Joaquim	*Malus domistica*; pH 5.3, 42 ppm P	Dry^1
CL519	*G. etunicatum*	Sieverding/Valle, Caicedonia	CIAT C-116-4; *Manihot esculenta*	Dry^2
CL780	*G. etunicatum*	Pellet/Valle, Palmira	CIAT C-125-2; *Glycine max*	N$_2$
FL216	*G. etunicatum*	Schenck/ Gainesville	Horticulture greenhouse	N$_2$
FL236	*G. etunicatum*	Sylvia/ Chiefland	Soil from roots of Dogwood in nursery	N$_2$
FL252	*G. etunicatum*	Johnson/ Gainesville*	*Baccharis halimifola*, Grace & Son phos. mine	N$_2$
FL425	*G. etunicatum*	Schenck/ Gainesville*	No information	N$_2$
FL452	*G. etunicatum*	Jarstfer/ Micanopy	*Zea mays*; garden sample	N$_2$
FL670-1	*G. etunicatum*	Dudeck/ Gainesville	Contaminant growing out in FL130 culture	Dry^1
GA150	*G. etunicatum*	Bryan/ Athens	*Liquidambar formosana*	N$_2$
GA319	*G. etunicatum*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	N$_2$
GA322	*G. etunicatum*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	N$_2$
GA329	*G. etunicatum*	Miller/ Blairsville	*Malus domestica*; in pasture before; Evard loam, pH 5.8, 13 ppm P	Dry^1
KS884-2	*G. etunicatum*	Hetrick/ Manhattan	Cultured on *Sorghum sudanense*	Dry^1
KY159	*G. etunicatum*	Hendrix/ Lexington	*Nicotiana* sp.	N$_2$
MD107-1	*G. etunicatum*	Millner/Beltsville Expt. Farm	Lima bean/sunflower plots; no growth promotion on sorghum/soybean	Dry^1

INVAM Isolate	**Fungal Species**	**Source Person/ Origin**	**Host-Soil-Environment**	**Store**
MD108	*G. etunicatum*	Watson/ Beltsville*	Pasture; pH 4.0	Dry^2
MS101-1	*G. etunicatum*	Maddox/ Natchez	Culture of Int'l Paper Co.; growth response in hi P soil, reduced Mn toxicity	Dry^2
ND269-2	*G. etunicatum*	Stack/ Fargo*	*Koelaria crestata*, native prairie	Dry^2
NE108A-2	*G. etunicatum*	Watson/ Lincoln*	Trap from MS research	Dry^1
NE109	*G. etunicatum*	Watson/ Lewellan	No information at this time	Dry^1
NY328B-2	*G. etunicatum*	Miller/ Geneva	*Malus domestica*; first in sorghum; Collamer silt loam, pH 6.6, 22 ppm P	Dry^2
PA137	*G. etunicatum*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry^1
SC504A	*G. etunicatum*	Skipper/ Clemson	MB-fumigated wheat field; native fungi in soybean host	P
SC602	*G. etunicatum*	Skipper/ Clemson	MB-fumigated wheat field; trapped soybean; native fungi	Dry^1
UT127	*G. etunicatum*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^2
UT186-2	*G. etunicatum*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^1
UT315-1	*G. etunicatum*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^1
UT316A-2	*G. etunicatum*	Wood/Salt Lake City*	Inoculum sold commercially by Native Plants Inc.	Dry^2
UT876	*G. etunicatum*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^1
WV579A-1	*G. etunicatum*	Morton/ Pumpkintown	*Trifolium pratense*; reclaimed coal mine, pH 4.6, 4 ppm P, 2% o.m.	Dry^1
WV977-1	*G. etunicatum*	Morton/ Masontown	*Phleum pratense* in pasture; pH 4.6, 5.2 ppm P	Dry^2
AZ201	*G. etunicatum/ Glomus* sp.	Stutz/Tempe	*Gossypium hirsutum*; alkaline soil	Dry^2
PA113	*G. etunicatum/ G. intraradices*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry^1
PA121	*G. etunicatum/ G. intraradices*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry^1
VZ102	*G. etunicatum/ G. occultum*	Leal/ El Tigre	pH 4.7, 9.3 ppm P, 22% Al saturation, < 1% o.m.	Dry^2
SC204	*G. etunicatum/ A. mellea*	Skipper/ Clemson	MB-fumigated wheat field; trapped after soybean; FL906 added	Dry^1

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
WV979-1	*G. etunicatum/ G. clarum*	Morton/ Sabraton	*Robinia pseudoacacia*; pH 4.5, 24 ppm P, 6 meq Al	Dry^3
UT126-2	*G. etunicatum/ G. intraradices*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry^2
NE102-1	*G. etunicatum/ G. occultum*	Watson/ Lincoln*	Trap from MS research	Dry^1
SC101	*G. etunicatuml G. occultum*	Skipper/ Clemson	Previously cropped to *Triticum aestivum*	Dry^2
TX104-1	*G. etunicatum/G. intraradices*	Taber/ College Station	Peanut trials, cultivated soil	Dry^2
NB120	*G. etunicatum?*	Klopatek/ Eastern Plains	*Stipagrostis cilliata* (grass)	Dry^1
NB124	*G. etunicatum?/ G. occultum*	Klopatek/ Eastern Plains	*Stipagrostis obtusa*	Dry^1
NE201	*G. fasciculatum?*	Watson/ Mead	Soil at pH 6.5	Dry^1
UK300	*G. fasciculatum?*	Cargeeg/ Rothamsted	No information at this time	P
DN987-3	*G. fistulosum*	Skou/Askov	Isolate #21; *Triticum aestivum*; sandy loam	Dry^1
DN988-3	*G. fragilistratum*	Skou/Funen	Cultotype; *Hordeum vulgare*; sandy loam	Dry^1
NE202	*G. geosporum*	Watson/ Mead	Soil at pH 6.5	Dry^1
PA116	*G. geosporum/ G. etunicatum*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry^1
IN101	*G. geosporum?l G. intraradices*	Kemary/Ambia Prairie	Undisturbed prairie.	P
FL325A	*G. globiferum*	Jarstfer/ Atlantic Beach	*Uniola paniculata*; pioneer sand dune	Dry^1
KS906-3	*G. intaradices*	Hetrick/ Manhattan	From Konza prairie plant community	Dry^1
AU109-1	*G. intraradices*	Gazey/Merredin	Uncertain origin; contaminant of WUM 10(1).	Dry^1
AZ112	*G. intraradices*	Stutz/Queen Creek	*Prosopis julifolia*; arid desert, pH 7.7, EC = 0.52	Dry^2
BR202B-1	*G. intraradices*	Sturmer/ Joaquina	*Panicum* sp.; sand dune	Dry^1
FL208-2	*G. intraradices*	Nemec/ Orlando	Citrus orchard; no plant growth responses	Dry^1
GR102-1	*G. intraradices*	Raschen/ Hanover	Isolate 515 trap culture using *Tagetes erecta*	Dry^2
GR104-1	*G. intraradices*	Raschen/ Hanover	Isolate #510 trap culture using *Tagetes erecta*	Dry^1
MI798-2	*G. intraradices*	Olexia/ Kalamazoo	No information at this time	Dry^3
MI894-1	*G. intraradices*	Safir/East Lansing	No information at this time	Dry^3

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
MN352	*G. intraradices*	Pfleger/ Lamberton	*Glyceria* adjacent to taconite tailings; pH 5.4, 37 ppm P, 212 ppm Fe.	P
NE106	*G. intraradices*	Watson/ Lincoln*	Trap from MS research	Dry[2]
NE108B-2	*G. intraradices*	Watson/ Lincoln*	Trap from MS research	Dry[1]
PA132	*G. intraradices*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry[1]
SC506	*G. intraradices*	Skipper/ Clemson	MB-fumigated wheat field; native fungi in soybean host	P
SW101	*G. intraradices*	Raschen/ Basel	Isolate T6 trap culture using *Physalis* and *Zea*	Dry[2]
SW103-1	*G. intraradices*	Raschen/ Basel	Isolate D13 trap culture using *Zea mays*	Dry[1]
UT118-1	*G. intraradices*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[2]
UT125-1	*G. intraradices*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[1]
UT143-2	*G. intraradices*	Wood/Salt Lake City*	Inoculum sold commercially by Native Plants Inc.	Dry[1]
UT176-1	*G. intraradices*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[1]
UT187-1	*G. intraradices*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[1]
VA102A-3	*G. intraradices*	Walker/ Assateague	*Ammophila brevigulata*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry[2]
WV795A-1	*G. intraradices*	Morton/ Jane Lew	*Trifolium pratense* in grazed pasture; pH 5.8	Dry[1]
WV944-1	*G. intraradices*	Morton/ Jane Lew	*Trifolium pratense* in pasture; pH 5.9, 13 ppm P	Dry[2]
WV968-1	*G. intraradices*	Morton/ Kingwood	Old pasture, *Festuca arundinacea*; pH 4.9	Dry[1]
WV994A-1	*G. intraradices*	Morton/ Brandonville	*Panicum* sp.; pH 4.4, 11 ppm P.	Dry[3]
NB101	*G. intraradices/ G. diaphanum?*	Jacobson/ Walvis Bay	Pooled soils from dune transect	Dry[2]
SC105	*G. intraradices/ Glomus sp*	Skipper/ Clemson	MB-fumigated wheat field; trapped after one season of soybean	Dry[1]
HA692-1	*G. intraradices/ G. mosseae*	Koske/Polihale State Beach	*Scaevola sericea*; sand dune	Dry[1]
TX144	*G. intraradices/ G. mosseae*	Stutz/Tornillo	*Prosopis pubescens*; arid desert, pH 7.7, EC = 12.2	Dry[1]
SC768-1	*G. intraradices/ Glomus* sp.	Skipper/ Clemson	From bahia grass pot culture	Dry[1]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
SC191	*G. intraradices/ G. claroideum*	Skipper/ Clemson	Soybean in R2 stage from wheat field; roots as inoc.; SC186-1 added	Dry[1]
SC188	*G. intraradices/ G. etunicatum*	Skipper/ Clemson	Soybean in V4 stage from wheat field; roots as inoc.; SC186-1 added	Dry[1]
SC189	*G. intraradices/ G. etunicatum*	Skipper/ Clemson	Soybean in V4 stage from wheat field; roots as inoc.; FL906 added	Dry[1]
SC190	*G. intraradices/ G. etunicatum*	Skipper/ Clemson	Soybean in V4 stage from wheat field; roots as inoc.; native fungi only	Dry[1]
SC306	*G. intraradices/ A. trappeil Glomus* sp.	Skipper/ Clemson	MB-fumigated wheat field; native fungi in soybean host	Dry[1]
AZ127	*G. intraradices?*	Stutz/Florence Junction	*Cercidium floridum*; Arid desert; alkaline soil	Dry[1]
CA111	*G. intraradices?*	Allen/ San Diego	*Artemisia tridentata* transplanted into pots	P
KY158	*G. intraradices?*	Hendrix/ Lexington	*Nicotiana* sp.	N_2
NB103-1	*G. intraradices?*	Klopatek/ Eastern Plains	*Stipagrostis cilliata* (grass)	Dry[2]
NB118	*G. intraradices?*	Klopatek/ Eastern Plains	*Orthanthera albida* (shrub)	Dry[1]
NB123	*G. intraradices?*	Klopatek/Semi-desert-savanna transition zone	*Commifera virgata* (shrub/tree)	Dry[1]
PL110	*G. intraradices?*	Blaszkowski/ Szczecin*	No information at this time	P
TL120	*G. intraradices?*	Supaporn/ Bangkok	No information at this time	Dry[2]
UT163-2	*G. intraradices?*	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[2]
AU210	*G. invermaium*	Gazey/Merredin	WUM 10(1); cape weed-clover pasture, 300 kg/ha superphosphate added	Dry[1]
ON393	*G. lamellosum*	Dalpé/Wasaga Beach	*Ammophila breviligulata*	Dry[1]
FL184-1	*G. leptotichum*	Schenk/ Gainesville*	No information	Dry[2]
VZ856-2	*G. leptotichum*	Carreno/ Guanare	*Alysocarpus vaginalis*; pasture	Dry[1]
FL491	*G. maculosum*	Schenck/ Gainesville*	No information	N_2
AZ130	*G. mosseae*	Stutz/Florence Junction	*Cercidium floridum*; Arid desert; alkaline soil	Dry[1]
CA106	*G. mosseae*	Watson/ Beltsville*	From Mihara; cultured on corn, pH 7.6	P

INVAM Isolate	**Fungal Species**	**Source Person/ Origin**	**Host-Soil-Environment**	**Store**
CL378	*G. mosseae*	Sieverding/ Valle Palmira	CIAT C-30-1; *Manihot esculenta*; pH 7.6, 50 ppm P, 1.7% o.m.	N_2
FL101-2	*G. mosseae*	Not specified	No information	Dry[1]
FL156B	*G. mosseae*	Schenck/ Gainesville	*Glycine max*; SE corner of agronomy farm	Dry[2]
FL205	*G. mosseae*	Schenck/ Live Oak	*Glycine max*	N_2
FL299-2	*G. mosseae*	Schenck/ Gainesville	No information	Dry[1]
FR113	*G. mosseae*	Millner/ Beltsville*	from INRA; pH 7.6	Dry[2]
GR583	*G. mosseae*	Dehne/ Hannover	No information	N_2
MD118	*G. mosseae*	Millner/ Beltsville*	From sand culture; pH 7.6	Dry[2]
MD122	*G. mosseae*	Millner/ Beltsville	From sand culture; pH 7.6	Dry[2]
NE107	*G. mosseae*	Watson/ Lincoln*	Trap from MS research	Dry[2]
OR229	*G. mosseae*	Trappe/ Corvallis*	No information	Dry[2]
UK125	*G. mosseae*	Millner/ Beltsville*	Isolate G1 of Jeffries; cultured on corn, pH 7.6	Dry[1]
UK126	*G. mosseae*	Millner/ Beltsville*	Isolate G2 of Jeffrioes; cultured on corn, pH 7.6	Dry[1]
UK127	*G. mosseae*	Millner/ Beltsville*	Isolate G3 of Jeffries; cultured on corn; pH 7.6	Dry[1]
UT101-2	*G. mosseae*	Wood/Salt Lake City	Information proprietary to Native Plants, Inc.	Dry[2]
WV692-2	*G. mosseae*	Morton/ Morgantown	*Zea mays*, Agronomy farm, pH 6.8, 27 ppm P	Dry[1]
NV102	*G. mosseae/ Glomus* sp.	Bethlenfalvay/ Bedell Flat	*Artemesia tridentata*; Mollic Haplargids, pH 5.1, < 1 ppm P	Dry[1]
PA115	*G. mosseae/ G. intraradices*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry[1]
PA122	*G. mosseae/ G. etunicatum*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry[1]
PL113	*G. mosseae/ Glomus* sp.	Blaszkowski/ Szczecin*	No information at this time	P
FL365	*G. mosseae/ G. caledonium*	Schenck/ Gainesville*	No information at this time	N_2
FL156A	*G. mosseae/ G. etunicatum*	Schenck/ Gainesville	*Glycine max*; SE corner of agronomy farm	Dry[1]
WV902-2	*G. mosseae/ G. intraradices*?	Morton/ Jane Lew	*Trifolium pratense* field; pH 6.1, 16 ppm P	Dry[2]
MT900-1	*G. mosseae/ Glomus* sp.	Grey/ Erpelding	*Hordeum vulgare*	Dry[1]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
PA104	*G. mosseae/G. claroideum?*	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry^1
SY710-1	*G. mosseae?*	Sands/Allepo	*Hordeum vulgare* nursery	Dry^1
BR219	*G. occultum*	Sturmer/Santa Catarina Island	*Tibouchina urvilleana*; pioneer sand dune	Dry^1
CL383-2	*G. occultum*	Schenck/ not specified	Information not provided; labelled *E. schenckii*	Dry^1
CL561	*G. occultum*	Sieverding/Cuaca, Quilichao	CIAT C-1-3; pH 4, 2.7 ppm P, 4.8 meq Al, 6% o.m.	N_2
CL699-1	*G. occultum*	Sieverding/ Cauca, Quilichao	CIAT C-29-2; native grasses; pH 4.3, 2 ppm P, 2.8 meq Al, 7.1% o.m.	Dry^3
CL700	*G. occultum*	Sieverding/Cauca, Quilichao	CIAT C-29-2 parent in immunological study.	Dry^1
CL700A	*G. occultum*	Sieverding/Cauca, Quilichao	Single spore culture from CL700 parent	Dry^1
CL700B	*G. occultum*	Sieverding/Cauca, Quilichao	Single spore culture from CL700 parent	Dry^1
CL707	*G. occultum*	Sieverding/ Magdalena	CIAT C-50-2; *Manihot esculenta*	N_2
CL741	*G. occultum*	Keller-Grein/ Meta, Vichada	CIAT C-163-4	N_2
CL785	*G. occultum*	Sieverding/Cauca, Pescador	CIAT C-115-3; *Manihot esculenta*	N_2
CL794	*G. occultum*	Pellet/Valle, Palmira	CIAT C-125-11; *Glycine max*	N_2
CL814	*G. occultum*	de Castellano/ Cundinamarca	CIAT C-135-1; *Pennisetum clandestinum*	N_2
CL824	*G. occultum*	Sieverding/Cauca, Mondomo	CIAT C-18-2; *Manihot esculenta*	N_2
FL276	*G. occultum*	Johnson/ Gainesville*	No information	N_2
FL667	*G. occultum*	Schenck/ Gainesville*	Contaminant in a pot culture	N_2
FL701-1	*G. occultum*	Schenck/ Gainesville	Contaminant from FL130 culture	Dry^3
FL703-1	*G. occultum*	Schenck/ Gainesville	Trap culture 62-S, no other information	Dry^3
HA771-2	*G. occultum*	Koske/Richardson Park	*Ichaemum* sp.; sand near surf line.	Dry^1
IA702-1	*G. occultum*	Walker/ Ames	Grasses and *Populus* sp.; Rhodes farm	Dry^3
IN433-1	*G. occultum*	Miller/West Lafayette	*Malus domestica*; silty clay loam, pH 5.8, 13 ppm P	Dry^1
WA434	*G. occultum*	Miller/ Wenatchee	*Malus domestica*; first in fallow; Burch loam, pH 6.6, 65 ppm P	N_2

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
CL697-1	*G. occultum/ Acaulospora* sp.	Sieverding/Cauca, Agua Blanca	CIAT C-19-3; *Manihot esculenta*; pH 4, 2.4 ppm P, 3.3 meq Al, 6% o.m.	Dry^2
NE105-1	*G. occultum/ Glomus* sp.	Watson/ Lincoln*	Trap from MS research	Dry^1
NC117	*G. occultum/ S. calospora*	Schultz/ Durham	Old field; site C-3-20	Dry^2
FL123	*G. sinuosum*	Schenck/ Homestead	Malanga, no. 7A in state survey	N_2
HA567-1	*G. spurcum* nom. ined.	Koske/ Puhimau	*Andropogon virginicus*; soil temp 33 C on surface, 50 C at 1" depth	Dry^2
NB102-1	*G. spurcum* nom. ined.	Klopatek/Semi-desert-savanna transition zone	*Pennisetum foermeranum* (grass)	Dry^2
NB106-1	*G. spurcum* nom. ined./*Glomus* sp.	Klopatek/ Eastern Plains	*Euclea pseudebenus* (shrub/tree)	Dry^2
AZ123	*G. spurcum*? nom. ined.	Stutz/ Wickenburg	*Prosopis julifolia*; Arid desert; alkaline soil	Dry^2
KS231	*G. versiforme*	Hetrick/ Manhattan*	*Sorghum sudanense*	N_2
OR231A	*G. versiforme*	Hetrick/ Corvallis*	*Sorghum sudanense*	N_2
FL986-2	*G. versiforme*?	O'Keefe/ Gainesville	Contaminant in S302 culture of Sylvia, pH 6.5	Dry^2
AU202	*Glomus* sp.	Gazey/Merredin	WUM 2(1); sandy-clay loam pasture, 7.5% clay, pH 7.5	Dry^1
AU203	*Glomus* sp.	Gazey/Merredin	WUM 3(1); sandy-clay loam pasture, 7.5% clay, pH 7.5	Dry^1
AZ117	*Glomus* sp.	Stutz/Queen Creek	*Cercidium floridum*; arid desert, pH 7.7	Dry^1
AZ225	*Glomus* sp.	Stutz/ Wickenburg	*Circidium floridium;* arid desert, pH 7.8, EC = 0.6	P
AZ235	*Glomus* sp.	Stutz/Verde River Wash	*Circidium floridium*; arid desert, pH 7.7	P
AZ283	*Glomus* sp.	Stutz/San Rafeal Valley	*Prosopis julifolia*; arid desert, pH 7.7	P
BR105	*Glomus* sp.	Spain/Brazilia*	No information at this time	Dry^1
BR107	*Glomus* sp.	Spain/Brazilia*	No information at this time	Dry^1
BR108	*Glomus* sp.	Spain/Brazilia*	No information at this time	Dry^1
BR212	*Glomus* sp.	Sturmer/ Videira	*Prunus persicae*; limed & fertilized Arguidoll soil	Dry^2
BR218	*Glomus* sp.	Sturmer/ Azambuja	*Vitis labrusca*; pH 6.2, 13.3 ppm P, 3.6% o.m.	Dry^2

INVAM Isolate	**Fungal Species**	**Source Person/ Origin**	**Host-Soil-Environment**	**Store**
CA110	*Glomus* sp.	Bethlenfalvay/ Anza Borrego	*Agave-Yucca*; moderate acidity, 5 mS/m salt	Dry[1]
CL569	*Glomus* sp.	Sieverding/ Valle, Bitaco	CIAT C-22-2; garden; *Allium porrum*	N_2
CL681	*Glomus* sp.	Castilla/ Antioquia	CIAT C-23-6; *Manihot esculenta*	N_2
FL312D-1	*Glomus sp.*	Sylvia/ Gainesville	Original isolate equal to FL924?	P
FL327	*Glomus* sp.	Jarstfer/ Anastasia Isle	Sand dune trap culture	Dry[3]
FL727	*Glomus* sp.	Sylvia/ Bartow	S331; *Styrax* sp.; pH 5.9, < 1 ppm P; Four Corners phosphate mine	N_2
FL906	*Glomus* sp.	Sylvia/ Gainesville*	S329. No other information available	N_2
FL924	*Glomus* sp.	Medina/ Ona	S 312; *Desmodium heterocarpum*	N_2
IN432	*Glomus sp.*	Miller/West Lafayette	*Malus domestica*; Brookston silty clay loam, pH 5.8, 13 ppm P	N_2
MT640	*Glomus* sp.	Grey/ Visser	*Hordeum vulgare*	Dry[1]
MT968-1	*Glomus* sp.	Grey/ Scyphers	*Hordeum vulgare*	Dry[1]
MX110	*Glomus* sp.	Stutz/ Mazacahui	*Prosopsis juliflora*; pH 7.6, EC = 0.62	P
MX111	*Glomus* sp.	Stutz/La Trinidad	*Prosopsis juliflora*; pH 7.5, EC = 0.3	P
NB104-1	*Glomus* sp.	Klopatek/ Eastern Plains	*Galenia fructicosa* (shrub)	Dry[2]
NB114-1	*Glomus* sp.	Klopatek/ Eastern Plains	*Geigeria ornativa*	Dry[2]
NB121	*Glomus* sp.	Klopatek/ Eastern Plains	*Galenia fructicosa* (shrub)	Dry[1]
NB122	*Glomus* sp.	Klopatek/ Eastern Plains	*Euclea pseudebenus* (shrub/tree)	Dry[1]
NB125	*Glomus* sp.	Klopatek/Semi-desert-savanna transition zone	*Myrothamnus flabelliofolia* (shrub)	Dry[1]
NB129	*Glomus* sp.	Klopatek/ Walvis Bay	*Welwitschia mirabilis*, gravel plains	Dry[1]
NB134	*Glomus* sp.	Klopatek/ Walvis Bay	No information at this time	Dry[1]
NC106-1	*Glomus* sp.	Schultz/ Durham	8-yr-old pasture; pH 6.7	Dry[1]
ND271	*Glomus sp.*	Stack/ Fargo*	*Stipa comata*, native prairie	N_2
NM110	*Glomus* sp.	Stutz/Santa Teresa	*Prosopsis glandulosa*; pH = 7.6, EC = 1.68	P

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
NV101	*Glomus* sp.	Bethlenfalvay/ Bedell Flat	*Artemesia tridentata*; Mollic Haplargids, pH 5.1, < 1 ppm P	Dry[1]
NV103	*Glomus* sp.	Bethlenfalvay/ Bedell Flat	*Artemesia tridentata*; Mollic Haplargids, pH 5.1, < 1 ppm P	Dry[1]
NY312	*Glomus sp.*	Miller/ Geneva	*Malus domestica*; first in sorghum; Collamer silt loam, pH 6.6, 22 ppm P	N_2
ON102-2	*Glomus* sp.	McGonigle/ Elora	*Zea mays* transplanted to turface; original soil pH 7.5, border w/ < 5 ppm P	Dry[2]
ON350	*Glomus* sp.	McKell/ Waterford	pH 7, 350 ppm P, 21 ppm N, 21 ppm Na	Dry[2]
PA107	*Glomus* sp.	Douds/ Wyndmoor	Low input trials; pH 6.5, 170 ppm P, 3% o.m.	Dry[1]
PL112	*Glomus* sp.	Blaszkowski/ Szczecin*	No information at this time	P
SA101	*Glomus* sp.	Germida/ Saskatoon	No information at this time	Dry[1]
SC306A	*Glomus* sp.	Skipper/ Clemson	MB-fumigated wheat field; trapped after one season of soybean; native fungi	P
TX237	*Glomus* sp.	Stutz/Tornillo	*Prosopis pubescens*; arid desert, pH 7.7, EC = 12.2	P
UK122-1	*Glomus* sp.	Morton/ Glen Coe	Grass in a field of *Calluna*; north slope	Dry[2]
UT110-1	*Glomus* sp.	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[1]
UT159-1	*Glomus* sp.	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[1]
UT179-2	*Glomus* sp.	Wood/Salt Lake City*	Information proprietary to Native Plants, Inc.	Dry[2]
WV105A-1	*Glomus* sp.	Blumbla/	Fly ash-amended minesoil, pH 7.8.	P
WV640-1	*Glomus* sp.	Morton/ Morgantown	*Festuca arundinacea*; mown hillside, pH 6.5, 39 ppm P	Dry[2]
WV925C-1	*Glomus* sp.	Morton/ Osage	*Robinia pseudoacacia*; black soil; pH 4.7, 11.8 ppm P, 5.2 meq Al	Dry[1]
HA903-1	*Glomus* sp./ *Acaulospora* sp.	Koske/Polihale State Beach	*Scaevola sericea*; sand dune	Dry[1]
BR201-1	*Gi. albida*	Sturmer/ Joaquina	*Ammophila*; sand dune	Dry[1]
BR202A-1	*Gi. albida*	Sturmer/ Joaquina	*Panicum* sp.; sand dune	Dry[1]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
BR205-3	*Gi. albida*	Sturmer/ Joaquina	*Ammophila*; sand dune	Dry^1
BR214	*Gi. albida*	Sturmer/Santa Catarina Island	*Spartina ciliata*; pH 6.1, 8 ppm P	Dry^2
FL185	*Gi. albida*	Schenck/ Gainesville	Contaminant in pot culture	N_2
FL927-3	*Gi. albida*	Pérez/ Gainesville	*Allium* sp.; park in town	Dry^2
MS975A	*Gi. albida*	Babson/South of Starkville	*Gossypium hirsutum*; muddy clay field soil	N_2
ND272	*Gi. albida*	Stack/ Fargo*	*Stipa comata*, native prairie	N_2
VZ106	*Gi. albida/ G. occultum*	Leal/ El Tigre	pH 4.9, 10 ppm P, 11% Al saturation, < 1% o.m.	Dry^2
AU102-3	*Gi. decipiens*	Gazey/Harvey	WUM 6(1). From irrigated *Paspalum-Trifolium repens* paddock	Dry^1
BR982	*Gi. decipiens*	Maia/ Pernambuco	*Gossypium hirsutum*; pH 6.1; low P	N_2
FL109	*Gi. gigantea*	Schenck/ North Florida	*Glycine max*	N_2
MA453A-2	*Gi. gigantea*	Koske/Horeseneck Beach	*Ammophila breviguIata*; sand dune	Dry^1
MN922A-1	*Gi. gigantea*	Johnson/ St. Paul*	Originally *A. trappei*. No other information	Dry^1
NC110A-1	*Gi. gigantea*	Schultz/Durham	Old field; site C-0-15	Dry^1
NC111B-1	*Gi. gigantea*	Schultz/Durham	Old field; site B-18-51	P
NC115B-1	*Gi. gigantea*	Schultz/Durham	Old field; site D-10-39	P
NC119B-1	*Gi. gigantea*	Schultz/Durham	Old field; site D-8-54	Dry^1
NC132	*Gi. gigantea*	Schultz/Durham	Old field; site A-13-11	Dry^1
NC133	*Gi. gigantea*	Schultz/Durham	Old field; site B-2-7	Dry^1
NC134	*Gi. gigantea*	Schultz/Durham	Old field; site B-26-40	Dry^1
NC135	*Gi. gigantea*	Schultz/Durham	Old field; site B-19-27	Dry^1
NC137	*Gi. gigantea*	Schultz/Durham	Old field; site C-26-36	Dry^1
NC138	*Gi. gigantea*	Schultz/Durham	Old field; site C-15-25	Dry^1
NC139	*Gi. gigantea*	Schultz/Durham	Old field; site D-10-45	Dry^1
VA101A-1	*Gi. gigantea*	Walker/ Asateague	*Solidago sempervirens*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry^1
VA103C-2	*Gi. gigantea*	Walker/ Assateague	*Solidago sempervirens*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry^1

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
VA105C-1	*Gi. gigantea*	Walker/ Assateague	*Ammophila brevigulata*; sand dune	Dry[2]
VA106A-2	*Gi. gigantea*	Walker/ Assateague	*Ammophila brevigulata*; fine sand, pH 6.2-6.8, <10 ppm P	Dry[1]
HA150C-1	*Gi. gigantea/ G. occultum*	Koske/Kalapana Beach	*Cocos nucifer*; dune	Dry[1]
VZ107	*Gi. gigantea/A. scrobiculata*	Leal/ El Tigre	pH 4.9, 10 ppm P, 11% Al saturation, < 1% o.m.	Dry[2]
BR444-2	*Gi. margarita*	Schenck/ Minas Gerais	Forage crop; Latasol, on experimental farm	Dry[2]
WV205A-2	*Gi. margarita*	Kotcon/ Kearnysville	Peach orchard, pH 6.4. 36 ppm P	Dry[1]
BR939	*Gi. margarita* or *rosea*	Schenck/ Lavras	Mimosa; greenhouse pot culture	N_2
FL274	*Gi. margarita* or *rosea*	Johnson/ Tallahassee	*Eromochloa ophiuroides* Maclay Gardens	N_2
FL680	*Gi. margarita* or *rosea*	Schenck/ Gainesville	Univ. of Florida La Ponderosa Ligustrum plot	N_2
FL972	*Gi. margarita* or *rosea*	Schenck/ Gainesville	UF La Ponderosa Ligustrum field plot	N_2
BR151A-2	*Gi. rosea*	Ming Lin/ Campinas*	Information not provided	Dry[1]
FL105-4	*Gi. rosea*	Schenck/ Gainesville	*Glycine max*	Dry[1]
FL219A-2	*Gi. rosea*	Schenck/ Gainesville*	No information	P
FL676-2	*Gi. rosea*	Schenck/ Gainesville	Single-spore isolate of FL105 from Florida	Dry[1]
GA201	*Gi. rosea*	Roncadori/ Athens*	Used in studies of nematode interactions	Dry[1]
NC108	*Gi. rosea*	Schultz/Durham	8-yr-old pasture; pH 6.7	Dry[2]
NC114B-1	*Gi. rosea*	Schultz/Durham	Old field; site D-24-33	Dry[1]
NC121A-1	*Gi. rosea*	Schultz/Durham	Old field; site A-12-36	Dry[1]
NY328A-2	*Gi. rosea*	Miller/ Geneva	*Malus domestica*; first in sorghum; Collamer silt loam, pH 6.6, 22 ppm P	Dry[1]
UT102-1	*Gi. rosea*	Walker/ Edinburgh*	Originally from Native Plants, Inc., no other info	Dry[2]
FL219-1	*Gi. rosea/ A. mellea*	Schenck/ Gainesville*	No information	Dry[1]
VZ105	*Gi. rosea/ Acaulospora* sp.	Leal/ El Tigre	pH 4.9, 10 ppm P, 11% Al saturation, < 1% o.m.	Dry[2]
BR155-1	*Gi. rosea/ S. heterogama*	Ming Lin/ Campinas*	No information	Dry[2]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
AU212	*S. calospora*	Gazey/ Badgingarra	WUM 12 (3); grasses; pH 4.4, 9 ppm P; no growth promotion	Dry^1
AU222	*S. calospora*	Gazey/ Badgingarra	WUM 12(2); Bush-land; fine sand, pH 4.8, 1 ppm P; no growth promotion	Dry^1
CL337-2	*S. calospora*	Sieverding/valle Buenaventura	CIAT MC-44-2; native grasses	Dry^1
CL370-2	*S. calospora*	Sieverding/ Popayan	CIAT C-3-7; *Manihot esculenta*; pH 4.8	Dry^1
NC111A-1	*S. calospora*	Schultz/Durham	Old field; site B-18-51	Dry^1
NC114A-1	*S. calospora*	Schultz/Durham	Old field; site D-24-33	P
NC115A-1	*S. calospora*	Schultz/Durham	Old field; site D-10-39	Dry^1
NC121B-1	*S. calospora*	Schultz/Durham	Old field; site A-12-36	P
NC128	*S. calospora*	Schultz/Durham	Old field; site A-21-16	Dry^1
NC129	*S. calospora*	Schultz/Durham	Old field; site A-9-39	Dry^1
NC130	*S. calospora*	Schultz/Durham	Old field; site A-13-47	Dry^1
NC131	*S. calospora*	Schultz/Durham	Old field; site D-11-5	Dry^1
NC142	*S. calospora*	Schultz/Durham	Old field; site C-15-41	Dry^1
NC143	*S. calospora*	Schultz/Durham	Old field; site B-3-6	Dry^1
NJ103	*S. calospora*	Kyde/ Rutgers	Grasses under hardwood canopy	Dry^2
NY348-2	*S. calospora*	Miller/ Geneva	*Malus domestica*; first in sorghum; Collamer silt loam, pH 6.6, 22 ppm P	Dry^2
NV105	*S. calospora/ G. clarum?*	Allen/Reno	*Artemesia tridentata* transplanted to GH culture	P
CL288-1	*S. calospora/ G. occultum*	Barkdoll/Valle, Buenaventura	Native grasses; very acid	Dry^1
IA260	*S. coralloides*	Millner/ Beltsville*	Originally from B. Ames; Information not provided	Dry^1
WV109A-1	*S. dipurpurascens*	Morton/ Manown	*Andropogon virginicus*; pH 4.1, < 2 ppm P, 62% Al saturation	P
WV989-1	*S. dipurpurascens*	Morton/ Cassville	*Festuca arundinacea*; pH 5.7, 23 ppm P, 136 ppm K	Dry^1
MX921A-2	*S. dipurpurascens*	Varela/Mexico City	No information at this time	Dry^1
WV930-1	*S. dipurpurascens*	Morton/ Pumpkintown	*Festuca arundinacea*; reclaimed coal mine, pH 4.6, 4 ppm P, 2% o.m.	Dry^3

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
VA110	*S. erythopa/ G. intraradices*	Watson/ near D.C.	Garden plot	Dry^2
HA150B-1	*S. erythropa*	Koske/Kalapana Beach	*Cocos nucifer*, dune	Dry^1
MA453B-2	*S. erythropa*	Koske/Horeseneck Beach	*Ammophila brevigulata*; sand dune	Dry^1
RI275B-1	*S. erythropa*	Koske/ East Beach	*Ammophila brevigulata*; sand dune	Dry^1
VA101B-1	*S. fulgida*	Walker/ Asseague	*Solidago sempervirens*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry^2
VA103B-1	*S. fulgida*	Walker/ Assateague	*Solidago sempervirens*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry^1
VA105A-2	*S. fulgida*	Walker/ Assateague	Mix of *Ammophila* & *Solidago*; fine sand, pH 6.2-6.8, <10 ppm P	Dry^1
FL223	*S. gregaria*	Schenck/ Gainesville	No information	N_2
BR154C-2	*S. heterogama*	Ming Lin/ Campinas*	No information	Dry^3
FL139	*S. heterogama*	Not specified	No information	N_2
FL312B-1	*S. heterogama*	Sylvia/ Gainesville	Contaminant in S312 subculture at WVU	Dry^2
FL654-1	*S. heterogama*	Johnson/ Gainesville*	No information	Dry^1
FL678	*S. heterogama*	Schenck/ Gainesville*	No information	N_2
FL728A-2	*S. heterogama*	Sylvia/ Bartow	S332; *Liquidambar* sp; 1.2 ppm P; Bonnie Lake phosphate mine	Dry^1
FL876	*S. heterogama*	Sylvia/ Bartow	S334; *Myrica*, Four Corners phosphate mine	N_2
IL203-2	*S. heterogama*	Dawson/ Champaign	Morrow plots; in *Zea mays* since 1879	Dry^1
MS973	*S. heterogama*	Babson/South of Starkville	*Gossypium hirsutum*; muddy clay field soil	N_2
NC140	*S. heterogama*	Schultz/Durham	Old field; site B-19-27	Dry^1
NC141	*S. heterogama*	Schultz/Durham	Old field; site B-10-29	Dry^1
NC144	*S. heterogama*	Schultz/Durham	Old field; site A-21-16	Dry^1
ND340	*S. heterogama*	Stack/Fargo	Contaminant in ND269	N_2
NY320-2	*S. heterogama*	Miller/ Geneva	*Malus domestica*; first in pasture; Evard loam, pH 5.8, 13 ppm P	Dry^1

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
SN722-2	*S. heterogama*	Louis/ Natl. Univ.	*Macaranga triloba* (rain forest), clay loam, pH 3.3, 5.2 ppm P	Dry[1]
WV108	*S. heterogama*	Morton/ Manown	*Andropogon virginicus*; acid mine drainage; pH 3.7, 81% Al saturation	Dry[2]
WV858-4	*S. heterogama*	Morton/ Manown	*Andropogon virginicus*; near acid mine drainage, pH 3.8, 72% Al sat.	Dry[2]
VZ103	*S. heterogama/ G. etunicatum?*	Leal/ El Tigre	pH 4.9, 8 ppm P, 18% Al saturation, < 1% o.m.	Dry[2]
BR208	*S. pellucida*	Sturmer/Santa Catarina State	*Vitis labrusca*; pH 6, 13 ppm P, 3% o.m.	Dry[1]
CL750-1	*S. pellucida*	Sieverding/Cauca, Timbío	CIAT C-139-3B; garden, weed in Compositae	Dry[1]
CL776	*S. pellucida*	Sieverding/Cauca, Timbío	CIAT C-139-3A; garden, weed in Compositae	N_2
FL966-2	*S. pellucida*	Pérez/ Sarasota	Wild legume; pH 7.4	Dry[1]
WV104	*S. pellucida*	Morton/ Cassville	*Festuca arundinacea* with *Rosa multiflora*; pH 5.7, 23 ppm P, 136 ppm K	Dry[2]
WV205B-1	*S. pellucida*	Kotcon/ Kearnysville	Peach orchard, pH 6.4. 36 ppm P	Dry[2]
WV872-3	*S. pellucida*	Morton/ Pumpkintown	*Andropogon virginicus*; reclaimed coal mine, pH 4.6, 4 ppm P, 2% o.m.	Dry[2]
WV873-1	*S. pellucida*	Morton/ Pumpkintown	*Danthonia spicata*; reclaimed coal mine, pH 4.6, 4 ppm P, 2% o.m.	Dry[1]
WV935A-1	*S. pellucida*	Morton/ Rivesville	*Lotus corniculatus*; pH 5.2, 4.6 ppm P, 2.5% o.m.	Dry[3]
NC118	*S. pellucida/ Acaulospora* sp.	Schultz/Durham	Old field; site A-6-27	Dry[2]
MA461A-2	*S. persica*	Koske/Cape Cod Seashore	*Daucus carola*; sand dune	Dry[1]
VA102C-4	*S. persica*	Walker/ Assateague	*Ammophila brevigulata*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry[1]
BR100	*S. reticulata*	Spain/Brazilia*	No information at this time	Dry[1]
CL756	*S. reticulata*	Spain/ Brazilia*	No information at this time	Dry[1]
HA150A-1	*S. verrucosa*	Koske/Kalapana Beach	*Cocos nucifer*, dune	Dry[1]
VA102B-4	*S. verrucosa*	Walker/ Assateague	*Ammophila brevigulata*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry[1]

INVAM Isolate	Fungal Species	Source Person/ Origin	Host-Soil-Environment	Store
VA103A-1	*S. verrucosa*	Walker/ Assateague	*Solidago sempervirens*; fine sand (.37 mm ave.), pH 6.2-6.8, <10 ppm P	Dry[2]
VA105B-2	*S. verrucosa*	Walker/ Assateague	Mix of *Ammophila* & *Solidago*; fine sand, pH 6.2-6.8, <10 ppm P	Dry[1]
BR101	*Scutellospora* sp.	Spain/Brazilia*	No information at this time	Dry[1]
BR103	*Scutellospora* sp.	Spain/Brazilia*	No information at this time	Dry[1]
BR211	*Scutellospora* sp.	Sturmer/ Tres Barras	*Eucalyptus dunnii*, pH 5, 11 ppm P, 2.7% o.m.	Dry[1]
TL339	*Scutellospora* sp.	Nopamornbadi/ Bangkok*	Weed roots in a rice paddy area.	N_2

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SUMMARY

The new family Graphostromataceae is proposed to accommodate *Graphostroma*. The Calosphaeriaceae is revised to include *Calosphaeria* (syn. *Wegelina*), *Enchnoa*, *Jattaea*, the newly recognized *Pachytrype*, and *Pleurostoma* (syns. *Romellia*, *Togninia*, and *Erostella*). New combinations are proposed for *Pachytrype princeps*, *P. graphidioides*, *Calosphaeria discreta*, *Jattaea cornina*, *J. tympanoides*, *Pleurostoma minima*, *P. vibratilis*.

Many years ago Penzig and Saccardo (1897) described *Diatrype princeps* from undetermined wood in Java. Berlese (1902) illustrated this fungus, unusual in beaked, polystichous ascomata in dark green, compact, pulvinate stromata and in oblong nonstipitate asci. Berlese noted a resemblance to *Calosphaeria* and suggested, as he noted was recommended also by Saccardo, that the fungus could be placed in a separate genus *Pachytrype*. Rappaz (1987) excluded the fungus from the Diatrypaceae and indicated that it belonged in *Valsa*. The superficial resemblance to a diaporthaceous fungus is evident in sections through ascomata, where the asci are extremely numerous in the centrum. Only when the hymenial layer is exposed is the calosphaeriaceous arrangement of these asci evident, a characteristic that is readily overlooked. As a consequence, the same taxon has been described as *Diaporthopsis metrosideri* Roane & Fosberg (Roane and Fosberg 1983) and transferred to *Endothia* (Barr 1983); it is perhaps pathogenic on *Metrosideros collina* (Forst.) Gray subsp. *polymorpha* (Gaud.) Rock (Myrtaceae) in Hawaii. Another probable synonym is *Endothia viridistroma* Wehm.

from *Cercis canadensis* L. (Fabaceae) in Georgia. However, the fact that this fungus is known only from a legume host from the type locality and, moreover, that its anamorph *Endothiella viridistroma* Roane is reported to have conidia 5-6 x 1-1.5 µm (Roane in Roane et al. 1986, Wehmeyer 1936) cause us to defer a formal disposition until additional material and, we hope, cultures can be examined. The generic name suggested by Berlese is accepted and validated as

Pachytrype Berl. ex M. E. Barr, J. D. Rogers & Y. M. Ju, gen. nov.

Stromata vadosa vel pulvinata vel irregularia prosenchymata viridia vel brunnea. Ascomata monosticha vel polysticha rostrata. Asci unitunicati numerosi oblongi sessili spicati. Ascosporae hyalinae oblongae vel allantoideae unicellulares. Species typicus *P. princeps*.

Stromata shallow, rounded or irregular, or well developed as pulvinate or irregular masses, composed of interwoven hyphae and cells, greenish to brownish. Ascomata monostichous or polystichous, beaks becoming elongate. Asci unitunicate, numerous, oblong, sessile, in spicate configuration. Ascospores hyaline, oblong to allantoid, one celled. Type species *P. princeps*.

Pachytrype princeps (Penzig & Sacc.) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov.

Diatrype princeps Penzig & Sacc., Malpighia 11: 501. 1897.

Diaporthopsis metrosideri Roane & Fosberg, Mycologia 75: 165. 1983.

Endothia metrosideri (Roane & Fosberg) M. E. Barr, Mycologia 75: 930. 1983.

? *Endothia viridistroma* Wehm., Mycologia 28: 38. 1936.

Stromata erumpent, pulvinate to irregular, 2-15 mm, becoming coalescent, up to 10 cm long, soft and fleshy, dull black externally, internally composed of greenish gray interwoven hyphae and enlarged cells, extending as sterile base into substrate. Ascomata polystichous, globose or ovoid, 250-500 µm wide, 250-700 µm high; beaks short and papillate to elongate, up to 3000 µm long, 80-150 µm wide at base, tapered to apex, ostiolar canal periphysate; peridium of compressed rows of reddish brown cells, 20-30 µm wide. Asci 15-20(-30) x 3-5(-6) µm, oblong, sessile, numerous in spicate arrangement, octosporous; apical ring minute, nonamyloid. Paraphyses sparse, elongate, tapering from wide base. Ascospores 4-7(-8) x 1-1.5(-2) µm, hyaline, allantoid or oblong. Anamorph in culture *Cytospora*-like: Colony on 2% oatmeal agar (Difco) covering plate in ca. 3 wk, gray, appressed to lanose, producing pycnidia in ca. 5 wk. Pycnidia ca. 1 mm diam, single or confluent, somewhat leathery, internally convoluted, lined with short conidiophores terminating in two or more conidiogenous cells 11-18 x 1.5-2 µm, producing conidia phialidically. Conidia variable in shape and size, 3-17 x 1.5-2 µm, ellipsoid, allantoid, rod-shaped, individually hyaline, extruded from pycnidium in yellowish drop.

Material examined: JAVA: host indet. tree, sine loc. #833, as *Diatrype princeps* Penz. & Sacc. (PAD, TYPE). USA: GEORGIA: *Cercis canadensis*, Athens, Univ. Georgia campus, 30 Apr 1934, J. H. Miller, det. L. E. Wehmeyer 3634 as *Endothia viridistroma* (DAOM 120190, TYPE). HAWAII: *Metrosideros collina*, Island of Hawaii, Hawaii Volcanoes Nat'l Park, Chain of Craters Road, Puhimau Crater, 20 Mar 1977, M. K. Roane and F. R. Fosberg 56728 as *Diaporthopsis metrosideri* (NY, ISOTYPE); Kalopa State Park, 4 Oct 1992, B. K. Duffy (JDR); *Metrosideros* sp., dead, sine anno, W. Ko (JDR); *M. allina*, Saddle Road, Mile 18, 16 Aug 1991, R. L. Gilbertson, "Fungi of Hawaii" 17026 (NY, JDR). (JDR is the personal herbarium of J. D. Rogers.)

Roane and Fosberg (1983) described material from *Metrosideros* and determined it to be a species of *Phomopsis* having alpha (3-4 x 1 µm) and beta (7-14 x 1 µm) conidia. Their dried cultural material is identical to that described above. The variability in size and shape of conidia, which includes that noted in the literature, was observed by Rogers and Ju, who provided the above description. Sutton (personal communication) agreed that the anamorph could probably be accommodated in *Cytospora*, despite the variability in conidia.

Another calosphaeriaceous taxon that has posed problems is known from *Terminalia brassii* Exell. (Combretaceae) in Papua New Guinea. It evidently causes butt cankers of plantation trees. The stromata are shallow, bright greenish yellow to brownish internally, containing monostichous, beaked ascomata. This taxon is identical to that described as *Peroneutypella graphidioides* from *Terminalia catappa* L. in the Philippines, although the material available of that species is rather overmature. Rappaz (1987) placed *Peroneutypella* Berl., an illegitimate name, under *Eutypella*, but excluded *P. graphidioides* from the Diatrypaceae as a species of *Valsa*. Simpson (personal communication) has isolated the anamorph in culture and it is *Cytospora*-like as in *Pachytrype princeps*. Because of the reduced stromatic tissues and monostichous ascomata, the collections are recognized as a separate species of *Pachytrype*.

Pachytrype graphidioides (Syd. & P. Syd.) M. E. Barr, J. D. Rogers & Y.M. Ju, comb. nov.

Peroneutypella graphidioides Syd. & P. Syd., Philippine J. Sci. Sect. C, 9(2): 163. 1914.

Stromata subperidermal, erumpent, variable in size, 1 mm or larger and irregular by confluence, surface brown, internally bright yellowish green to brown, composed of interwoven hyphae and granular material. Ascomata monostichous in base of stroma, 220-275 µm wide, 165-180 µm high; beaks 550-770 µm high or longer, 65-80(-90) µm wide near base, tapering to apex; peridium brown, compressed rows of cells, 10-40 µm wide. Asci 18-22 x 4-5 µm, oblong, sessile, numerous in spicate arrangement, octosporous; apical ring refractive, shallow, nonamyloid. Paraphyses sparse, elongate. Ascospores 4-5 x 1-1.5 µm, hyaline, allantoid, one-celled.

Material examined: PHILIPPINE ISLANDS: *Terminalia catappae*, Taytay, Palawan, Apr 1913, E. D. Merrill Flora of the Philippines No. 8724 as *Peroneutypella graphidioides* n.sp. (BPI, NY). PAPUA NEW GUINEA: *T. brassii*, Madang Prov., Baku, Gogol Valley, J. A. Simpson, Feb 1979, n. 1971, 26 Feb 1979, n. 1976, Mar 1979, n. 1978 (NY, part).

A collection from Alabama (Huhndorf 44, NY) on old decorticated wood is quite similar, but the narrow stromatic layer is pallid to light brown and granular. The asci measure only 12-15 x 4-5 µm, whereas ascospores are 5-6 x 1 µm. Still other candidates for inclusion are some long-beaked taxa known in culture, two of them isolated from stains associated with bark beetle galleries: *Togninia fraxinopennsylvanica* (Hinds) Hausner, Eyjólfsdóttir & J. Reid [*Calosphaeria fraxinopennsylvanica* (Hinds) Upadhyay] and *T. novae-zealandiae* Hausner, Eyjólfsdóttir & J. Reid. These species produce anamorphs that vary between *Acremonium* and *Phialophora* (Hausner et al. 1992).

Assimilation of the above information into a revised scheme of classification for the Calosphaeriaceae has led to certain changes. Earlier, Barr (1985) accepted eight genera: *Calosphaeria*, *Scoptria*, *Enchnoa*, *Jattaea*, *Romellia*, *Graphostroma*, *Togninia*, *Pleurostoma*. Rappaz (1987) clarified the status of *Scoptria* Nitschke and its illegitimate obligate synonym *Peroneutypella* Berl. as synonyms of *Eutypella*. Both names were based on *S. isariphora* Nitschke, which Rappaz disposed under the earlier name *Eutypella tetraploa* (Berk. & M. A. Curtis ex Berk. & Broome) Sacc. The species has stipitate asci, with an amyloid apical ring, that form a persistent hymenium, and pigmented ascospores. Barr (1990) took up *Wegelina* for similar calosphaeriaceous fungi and made additional changes based upon interpretation of typification by Berlese (1900). These included the revival of *Erostella* in place of *Togninia* for *Calosphaeria minima* Tul. & C. Tul., and the proposed retypification of *Jattaea* that did not change the generic concept. L. Holm (1992) has argued against accepting Berlese's typifications, and although valid arguments supporting them are available, a change in emphasis is proposed below which eliminates the problems.

Graphostroma platystoma (Schwein.) Piroz. remains in an anomalous position in the family, for the two-layered stroma, diatrypoid configuration of short-beaked ascomata, holoblastic conidiogenesis of the *Nodulosporium* anamorph, faintly amyloid apical ring in the asci (Pirozynski 1974, Glawe and Rogers 1986) differ, whereas the oblong, nearly sessile asci in spicate arrangement, sparse paraphyses that taper from a wide base, and hyaline suballantoid ascospores are characteristic of the Calosphaeriales. It seems reasonable to accept two families Calosphaeriaceae and Graphostromataceae within the order, separated by stromata and anamorphs but united by the unique centrum and hyaline, allantoid to oblong ascospores.

Graphostromataceae M. E. Barr, J. D. Rogers & Y. M. Ju, fam. nov.

Stromata effusa ex ectostromate conidiogeno *(Nodulosporium)* decidua et entostromate peritheciis inclusis compositim. Ascomata immersa rostellata. Asci unitunicati oblongi spicati. Paraphyses sparsim. Ascosporae hyalinae suballantoideae unicellularis. Genus typicus: *Graphostroma* Piroz.

Stromata effuse, two layered, conidiogenous ectostroma deciduous. Ascomata immersed in diatrypoid configuration in entostroma. Asci unitunicate, oblong, in spicate arrangement. Paraphyses sparse, elongate, tapering from wide base. Ascospores hyaline, suballantoid, unicellular. Type genus: *Graphostroma* Piroz.

The Calosphaeriaceae now includes genera whose members have one celled or delicately septate ascospores in octosporous or polysporous asci (as argued for other genera by Müller et al. 1987, Barr 1991). The asci are clavate and short stipitate or oblong and sessile, and ascomata are papillate or short beaked (up to diameter of ascoma) or elongate beaked in various configurations. The following key serves to separate genera.

1. Asci clavate, short stipitate, fasciculate............2
1. Asci oblong or subglobose, sessile, spicate..........4
    2. Ascomata long beaked, in valsoid configuration or separate to gregarious.................*Calosphaeria*
    2. Ascomata papillate or short beaked, separate to gregarious.....................................3
3. Ascomata small to medium sized, not in subiculum....... *Jattaea*
3. Ascomata large, in abundant subiculum..........*Enchnoa*

4. Ascomata long beaked, eutypoid in shallow byssoid granular stroma or polystichous in massive pulvinate stroma.................................*Pachytrype*
4. Ascomata papillate or short beaked, separate to gregarious or in valsoid configuration....*Pleurostoma*

In this revised version of the family, ***Calosphaeria*** includes the type species of *Wegelina*, whose ascomata are separate to gregarious, in addition to those species whose ascomata are arranged in valsoid configuration.
Calosphaeria discreta (Berl.) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov. Basionym: *Wegelina discreta* Berl. Icon. Fung. 3: 8. 1900. [*Wegelina sepulta* (Berk. & M. Curtis) Berl. is a synonym of *Eutypella scoparia* (Schwein.: Fr.) Ellis & Everh. (Rappaz 1987)].

Jattaea is the correct name for some species having clavate, fasciculate asci, once placed in *Romellia*.
Jattaea cornina (Peck) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov. Basionyn: *Valsa cornina* Peck, Ann. Rep. New York State Mus. 38: 102-103. (for 1884) 1885. *Calospora allantospora* Ellis & Everh. (J. Mycol. 9: 223. 1903) is a synonym according to the description, which is based upon the entity on *Cornus*, not that on *Acer*.
Jattaea tympanoides (M. E. Barr) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov. Basionym: *Romellia tympanoides* M. E. Barr, Mycologia 77: 561. 1985.

Pleurostoma encompasses both polysporous and octosporous species, including the type species of *Romellia*, *Togninia*, and *Erostella*.
Pleurostoma minima (Tul. & C. Tul.) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov. Basionym: *Calosphaeria minima* Tul. & C. Tul. Sel. Fung. Carp. 2: 112. 1863. (type species of both *Togninia* and *Erostella*). *Calosphaeria alnicola* Ellis & Everh. (Proc. Acad. Nat. Sci. Philadelphia 42: 221. 1890) is a synonym.
Pleurostoma vibratilis (Fr.) M. E. Barr, J. D. Rogers & Y. M. Ju, comb. nov. Basionym: *Sphaeria vibratilis* Fr. Syst. Mycol. 2: 482. 1823. (type species of *Romellia*).

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REDISPOSITION OF ELLIS TAXA: A CORRECTION

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Subsequent to preparation of a manuscript on redisposition of Ellis names (Barr 1993), a change in the generic position of one species necessitated replacement of several pages. Unfortunately, one page was omitted in transmission, and the result was one incorrect combination and the loss of a combination and description for another species. To correct this error requires the removal from page 62 of the lines following "Avalon, 14 Mar 1904, Pacific Slope F. 4041, isotype, NY)." (line 27) and replacement by the following to complete the page.

Linocarpon hamasporum (Ellis & Everh.) Barr, comb. nov. Fig. 2u

Ophiobolus hamaspora Ellis & Everh. J. Mycol. 3: 117. 1887.

Ascomata immersed, scattered thickly in leaf tissues, sphaeroid, collabent, 170-220 µm wide, 120-150 µm high; periphysate ostiole reaching lower leaf surface; peridium narrow, light brown, 10-12 µm wide, compressed rows of cells, blackened to form a narrow, apical clypeus. Asci 44-66 x 8-11 µm, oblong, unitunicate; apical ring shallow, nonamyloid, chitinoid. Paraphyses deliquescent. Ascospores 38.5-50 x 1-2 µm, hyaline, filiform, apex obtuse, tapered to base, one celled; wall thin, smooth; globules numerous, in a spiral fascicle in the ascus.

In leaves of *Quercus tinctoria* W. Bartram. Kansas: Manhattan, Jul 1887, W. T. Swingle "976", holotype (NY). Another collection is on *Q. maxima* = *Q. rubra* L., Tennessee: Greenbriar Cover, Great Smokey Mts. Nat'l Park, 13 Jun 1942, J. H. Miller (TENN 14300 under *Gnomonia setacea)*.

The ascospores of this species are typical of ascospores in *Linocarpon*, filiform and containing numerous globules. Hyde (1988) described them as numerous refringent, septum-like bands, but in the material examined the appearance is of a row of refractive

Barr, M. E. 1993. Redisposition of some taxa described by J. B. Ellis. Mycotaxon 46: 45-76.

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A DISASTROUS DECISION TO SUPPRESS THE TERMS ANAMORPH AND TELEOMORPH

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The purpose of this brief note is to call attention to what we feel are clear errors in reasoning on the part of some C•A•B International Mycological Institute (IMI) workers. During the recent meetings of NATO's First International Workshop on Ascomycete Systematics in Paris (11–14 May, 1993) it was announced that in the forthcoming eighth edition of *The Dictionary of the Fungi* the terms *anamorph* and *teleomorph* that had been used previously would be discarded, and *mitosporic fungus* and *meiosporic fungus* would be used instead. The rationale appears to be that mitosis and meiosis are terms well known to even elementary students of biology, and that such specialized terms as anamorph, teleomorph, and, indeed, holomorph, are inaccessible to the novice worker[3] outside of mycology. B. C. Sutton (in Reynolds & Taylor, 1993), in the symposium volume entitled *The Holomorph* being published by IMI, announces in print that in the eighth edition of the *Dictionary* the terms *mitosporic fungi* and *mitosporomata* will be used instead of deuteromycetes and conidiomata, and the terms *anamorph, conidium,* and *conidiogenesis* will be suppressed. It is not clear whether the terms *meiosporic fungus* and *meiosporogenesis* will then fully replace *teleomorph* and *ascosporogenesis / basidiosporogenesis,* respectively.

We believe this is a retrogressive decision, and that it can only confuse the clear distinction accepted at the Second Kananaskis Conference, and also embodied in the International Code of Botanical Nomenclature (ICBN). When it was pointed out by a participant in the Workshop that these terms—

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[3] The *Dictionary* is, of course, a research tool for professional mycologists, not elementary school students.

anamorph, teleomorph, and *holomorph*—appear there, the NATO Workshop Director, Professor David Hawksworth, also Director of IMI, quietly announced that "since we introduced the terms into Art. 59, we can just as easily remove them." [4] We call upon our colleagues not to give up the essential terms *anamorph* and *teleomorph* just because of an egregious editorial decision by the IMI staff.

What the IMI proponents of the new terminology have apparently forgotten is that the terms *anamorph, teleomorph,* and *holomorph* were specifically introduced as terms for use in *nomenclature.* Donk (1960) introduced the term *anamorphosis* as such a nomenclatural term, to indicate a state or "morph" of a fungus that might require a name but which was not the so-called "perfect" or "sexual" state on which the nomenclature of the whole ascomycetous or basidiomycetous fungus could be based. It was Hennebert and Weresub (1977) who introduced the new terms *teleomorph* and *holomorph,* simultaneously adopting Donk's use of *anamorph,* terms immediately recognized as unequivocal and exceptionally useful by the Tampa IMA Congress and the Second Kananaskis Conference (see Kendrick, 1979). One cannot equate these terms with those suggested for substitution by the proponents of their disuse.

First, the term *mitosporic fungus* implies that its nuclear divisions are mitoses, true certainly only for a majority of the nuclear divisions that occur in vegetative hyphae, in conidiogenesis, and in production of overwintering structures (e.g., sclerotia) or other means of "asexual" reproduction. On the other hand, *meiosporic fungi* are also composed of predominantly mitotic nuclei. Meiosis is but that brief moment when reduction division occurs, and using *meiotic fungus* merely states that the fungus at some point in its life cycle is *known* to undergo meiosis (and often the immediate production of spores resulting from that meiosis). In many basidiomycetes the four nuclei resulting from meiosis are separated into four uninucleate basidiospores, and such spores are indeed *meiospores.* But—in other basidiomycetes and in the very great majority of ascomycetes—meiosis is followed by one (or more than one) additional *mitotic* division prior to spore delimitation. An 8–spored basidium or an 8–spored (or 64–spored, or 7000+ –

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[4] The preposterous notion (see Reynolds in Reynolds & Taylor, 1993; also *pers. comm.* to GLH) that DNA technology will in the foreseeable future permit us to eliminate Art. 59 of the ICBN and no longer require names for anamorphs does not even merit rebuttal.

spored) ascus does not technically produce *meiospores,* but rather spores that are the result of one or more additional postmeiotic mitoses. Such *spores* are acceptably termed basidiospores or ascospores, since they are borne on or in a basidium or ascus, a *meiosporangium* (the sac in which meiosis occurs in ascomycetes and basidiomycetes). Alternatively, one could redefine *meiospore* to mean any spore produced on or in a meiosporangium, not a spore resulting from meiosis.

In what could better be termed “mitotic fungi” (surely not “mitosporic fungi”) there may be mitotic structures (morphs) that require naming, and if we abandon *anamorph* as the term to apply to such elements, we are left with nothing applicable under the newly proposed terminology. Consider for example a pleomorphic fungus such as *Botryotinia fuckeliana,* with both a teleomorph (the sclerotiniaceous apothecial state bearing asci) and several other morphs, including a *Botrytis* conidial apparatus, a *Sclerotium* state, a *Myrioconium* spermatial state (if the “spermatia” can occasionally germinate, as has been reported, then this state might better be termed “microconidial” rather than “spermatial”), an unnamed appressorial state, and an unnamed vegetative mycelial state. Though the *Botrytis* state can be said to produce mitospores, and to undergo mitosporogenesis, it is less clear that the “spermatia” are “mitospores” or undergo sporogenesis or spermatogenesis, and certainly the vegetative states (*Sclerotium* spp. and *“Hypha”* spp.) are not sporal at all. Those who would argue that we don’t need names for agonomycetous states or for spermatial states ignore reality. Not only is the genus *Sclerotium* needed for fungi which produce no conidial apparatus, but such genera as *Rhizoctonia, Ascorhizoctonia,* and *Ozonium,* to name a few, are far too critical to ignore or to leave without a term equating them to other name-bearing morphs. Those who would contend that spermatial states are not anamorphs (a position voiced by an eminent lichenologist at the Ascomycete Workshop) are equally blind to the fact that many so-called conidial fungi may instead be spermatial states. The germinability of the “spores” of such fungi has not been demonstrated for a very large proportion of the species. Many species of *Phoma,* for example, are demonstrably spermatial states, not conidial states. In the Uredinales, the generic name *Aecidiolum* is available for at least some spermatial states. The generic name *Myrioconium* is used throughout most of the Sclerotiniaceae for the evident spermatial states of these discomycetes. It is our contention that when a fungus in culture, for example, produces only ascocarps and no associated conidial state (and no spermatial state, or perhaps an overlooked one), it is wrong to say that only a teleomorph is produced. All teleomorphic ascomycetous and basidiomycetous fungi have in addition to the ascal or basidial state an indeterminate number of other (normally, luckily, *unnamed*) morphs, at least one of which could typically be assigned to the agonomycetous genus *Hypha*.

It is clear to us that *mitospore* and *anamorph* share some characters, but they are not, and cannot be treated as, synonymous. Similarly *meiosporic fungus* and *teleomorph,* though sharing characters, are not synonymous. (See Weresub & Hennebert, 1979). *Mitospore, spermatium,* and *conidium* are also not synonymous. The terms *mitospore* and *meiospore* are useful karyological terms, but they do not and cannot replace clear terms such as *conidium, ascospore,* or *basidiospore.* Application of the term *mitosporic fungus* to members of the Mycelia Sterilia (Agonomycetales) as proposed by Sutton (1993) as a ninth type of *"mitosporomata"* is simply incomprehensible, since no spores are involved. Such terminology is clearly counterproductive.

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BOOK REVIEWS

L. M. Kohn, Book Review Editor

Distribution and Ecology of Stipitate Hydnaceous Fungi in Norway, with Special Reference to The Question of Decline, by G. Gulden and E. W. Hanssen. Sommerfeltia 13. Softcover, 182 x 257 mm, 58 pp., 1992. Sommerfeltia is a series of monographs in plant taxonomy, plant ecology, plant morphology, and evolutionary Botany, available from: Botanical Gardens and Museum, Univ. of Oslo, Trondheimsveien 23B, N-0562 Oslo 5, Norway. ISBN 82-7420-014-4, ISSN 0800-6865. NOK 110.

Stipitate hydnaceous fungi are considered in Central Europe to be sensitive bioindicators of airborne pollution, in particular nitrogen deposition, and many species are included in Red Lists of endangered fungi in several countries. These facts inspired Gulden and Hanssen to describe and analyze the distribution patterns of 28 species native to Norway, belonging to the genera *Auriscalpium* (1), *Bankera* (2), *Hydnellum* (10), *Hydnum* (2), *Phellodon* (4), and *Sarcodon* (9). Dot maps of all species are presented and the relative frequencies of the more common species in the period up to 1949 and four decades afterward are indicated in histograms. On the basis of the maps, the species are arranged in five geographical groups. For each species, details are provided on distribution patterns within and without Norway, as well as their ecological and temporal trends. A possible decline was noticed for only three species.

In studies on the distribution of fungi it is often questionable whether the maps represent real patterns or rather the intensity of collecting. I had such doubts here since over half of the records of 18 species were from the vicinity of Oslo, covering less than 5% of Norway. This concentration might very well be an artifact, at least for some species. Conclusions on decrease were based on numbers of records in different periods, but it is difficult to establish whether the recording frequency has remained constant over the years. Theoretically, rare and declining species might even be over-represented in the material, since mycologists tend to pay more attention to such species. However, I realize that it is easy to criticize these methodological problems, but difficult to suggest alternatives.

The booklet may stimulate Norwegian and other mycologists to fill the gaps in the distribution maps of these fascinating fungi and it is a valuable source of information for future monitoring. Of interest to mycologists involved in mapping and monitoring, as well as to specialists in hydnaceous fungi. *E. Arnolds, Biological Station, Agricultural University, Wijster, 9418 PD Netherlands.*

Macromycetes and Air Pollution. Mycocoenological Studies in Three Oligotrophic Spruce Forests in Europe, by G. Gulden, K. Høiland, K. Bendiksen, T. E. Brandrud, B. S. Foss, H. B. Jensen, & D. Laber. Bibliotheca Mycologica, Band 144. Softcover, 140 x 225 mm, 81 pp., 1992. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Johannesstr. 3 A, D-7000 Stuttgart 1, Germany [fax: (0711)625005]; U.S. Agent, Lubrecht & Cramer, R.D. 1, Box 244, Forestburgh, NY 12777 (fax: 914-791-7575). ISBN 3-443-59045-4. DM 50.--.

This publication treats the results of mycocoenological studies, carried out from 1986 through 1989, in forests of *Picea abies* in central Norway, southern Norway, and southern Germany (Black Forest). In each of the areas ten adjacent plots of 225 m^2 were sampled. The objectives of this study were to compare the characteristics of the macromycete communities in spruce forests along an air pollution gradient in Europe, ranging from almost virgin conditions in central Norway to heavily polluted conditions in the Black Forest. Care was taken to keep the other environmental factors as constant as possible. The booklet treats in a clear and compact style the areas of research, the methodology, and the results for ectomycorrhizal fungi, terricolous saprotrophs and lignicolous species, respectively. The data are treated statistically in an adequate way and are presented in the form of numerous figures, graphs and tables. In the discussion, the data are compared with other mycosociological data on spruce forests in Europe and possible causes of differences in macromycete communities are discussed. It is concluded that the lower number of mycorrhizal species in the Black Forest is likely to be caused by the effects of air pollution, mainly acidification. The authors found that the Black Forest stands contain a high proportion of species containing secondary metabolites which may have the capacity to complex metal ions, such as Al^{3+}. This might be an adaptation to strongly acid soils with a high content of soluble aluminum. The possible use of macromycetes as indicator organisms for forest vitality and soil acidification is discussed. An extensive list of references completes the book.

I compliment the authors on the lucid way they treat the complex relations between fungi, forest health, soil factors and air pollution. As usual in this field, some questions remain unanswered, for instance, the relations between sporocarp productivity of mycorrhizal species and the below-ground productivity of mycorrhizal root tips. The possibility that spruce forests in the Black Forest have always been poorer in (mycorrhizal) macromycetes is not considered, apparently because historical data are lacking. The possible effects of nitrogen pollution on macromycetes are in my opinion underestimated in the discussion. However, these remarks do not affect the importance of this study in advancing our understanding of the interactions of macromycetes with air pollution. *E. Arnolds, Biological Station, Agricultural University, Wijster, 9418 PD Netherlands.*

An Illustrated Guide to Fungi on Wood in New Zealand, by I. A. Hood. Softcover, 148 x 210 mm, 424 pp., 1992. Auckland University Press, University of Auckland, Private Bag 92019, Auckland, New Zealand. ISBN 1-86940-063-1. N.Z. $39.95.

This attractive publication focuses on common species of fungi occurring on wood in New Zealand. Written for accessibility to a broad audience, the book includes informative sections on the natural history of New Zealand, the biology, ecology and economic impact of fungi, as well as figures illustrating pertinent anatomical features of fungi and wood decay. Keys are based on macroscopic characters and species are illustrated with line drawings accompanied by descriptions with references to primary literature. Eight composite color plates further illustrate selected examples. The appeal of this book is not confined solely to those with specific interests in the natural history and flora of New Zealand, but extends to those with broad interests in wood decay and associated fungi. *J. B. Anderson, Department of Botany, Erindale College, University of Toronto, Mississauga, Ontario, Canada L5L 1C6.*

Index to Saccardo's Sylloge Fungorum Volumes I-XXVI in XXIX 1882-1972, by C. F. Reed and D. F. Farr. Available in hardcover or softcover, 260 x 210 mm, 884 pp. + 4 pp. Clyde Reed, 1222 Main St., Darlington, Maryland 21034, U.S.A. Hardcover is $75.- plus $4.- shipping, Softcover is $60.-- plus $4.- shipping.

The **Sylloge Fungorum** provides lists of names and descriptions for fungi and bacteria known in the late 19th and early 20th century. A total of 121, 627 names in 4,827 fungal genera and 88 bacterial genera according to the authors of this index. In preparing this publication, Reed and Farr have overcome difficult logistical problems, including confusing pagination and inconsistencies in reprinting of the volumes, to provide the first cumulative index to this vital bibliographic resource. The index is organized into a conspectus of the volumes followed by the actual index of taxa organized under the generic names under which species appeared in the **Sylloge**. Quick perusal of selected epithets showed careful cross-indexing under all generic names to which the epithet had been assigned during the period covered by the **Sylloge**. This index is an important addition to the taxonomic literature. Note that a list of Saccardo's omissions was prepared by P. M. Kirk and published by C.M.I. in 1985. *L.M.K.*

MYCOTAXON

Volume XLVIII, pp. 547 July-September 1993

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NOTICE: FUNGI EXSICCATI SUECICI ISSUES NO. 3500

The issue of Fasicle 70 (Nos. 3451-3500) completes the seventh decade of:

FUNGI EXSICCATI SUECICI
PRAESERTIM UPSALIENSES

Mandatu Collegii ex Elia Friesio nominati
edendos curaverunt

L. Holm et J. A. Nannefelft (†)

This is the sixtieth year of the project initiated in 1932 by Seth Lundell (1892-1966) and John Axel Nannefeldt (1904-1985). The purpose of the set being the distribution of materials collected from the localities visited by Fries.

Fascicle seventy comprises fifty numbers of Discomycetes representing forty-one species of the families Hyaloscyphaceae, Hypodermataceae, Rhytismataceae, Phacidiaceae and Morchellaceae. Four new taxa are described; three new combinations are published. An alphabetic index and host index to nos 3001-3500 are appended. Along with specimens collected, determined and annotated by Nannefeldt, the most frequent contributor to the series, are those determined and in some cases described by Lennart Holm and "ardent fellow-mycologists" from Europe and North America.

Schedae for the latest fascicles are published in *Thunbergia* (ISSN 0283-2275), distributed by the Botanical Museum, Uppsala University, P. O. Box 541, S751 21 Uppsala, Sweden, and printing costs defrayed by the Swedish Natural Science Research Council.

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Page	13	line	29	*for*	CUP-M	*read*	CUP-ME
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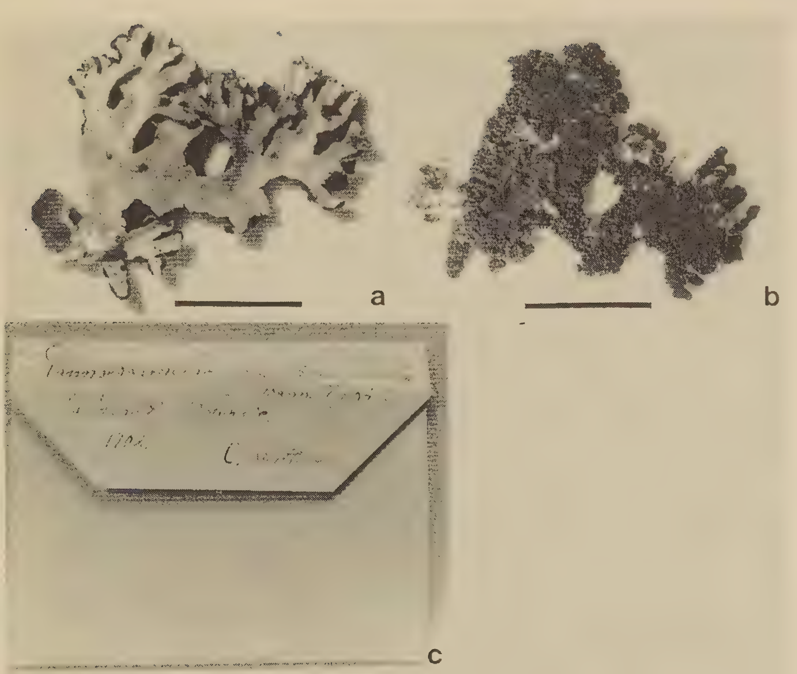
Page 117 of the article by Mónica Adler and Susana Calvelo, "New Reports of Parmeliaceae *s. str.* (Lichenized Ascomycotina) from Southwestern Argentina" which appeared on pp. 105-127 of the volume. Fig. 1 c. was lost during printing and is published here (see facing page) along with Fig. 1 a,b and Fig. 2 a, b.
Captions: Fig. 1 a-b: Thallus of *Pannoparmelia anzioides* collected by Skottsberg in 1902 (isotype) scale: 1 cm. See original manuscript of envelope (Fig. 1 c).
Fig. 2 Detail of lobules (arrows). a: *Parmelia saxatilis* (Collection #523). b: *Parmelia sulcata* (Collection #531). Scale 1 mm.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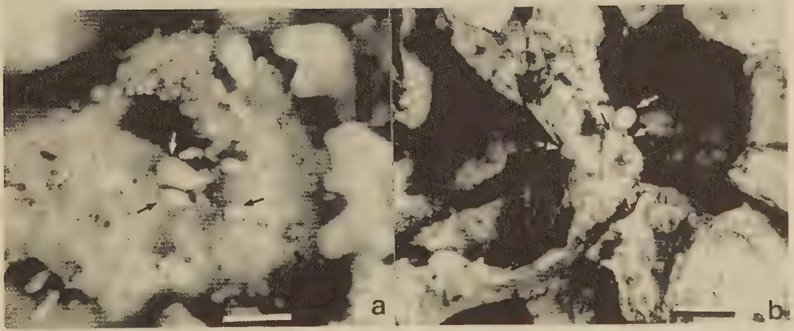
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